CORPS OF ENGINEERS, U. S. ARMY

MEMPHIS HARBOR
MISSISSIPPI RIVER

MODEL INVESTIGATION

TECHNICAL MEMORANDUM NO. 2-320

CONDUCTED FOR

THE PRESIDENT, MISSISSIPPI RIVER COMMISSION

CORPS OF ENGINEERS, U. S. ARMY

BY

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

ARMY-MRC-VICKSBURG, MISS.

DECEMBER 1950

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **DEC 1950**	2. REPORT TYPE	3. DATES COVERED **00-00-1950 to 00-00-1950**
4. TITLE AND SUBTITLE **Memphis Harbor, Mississippi River: Model Investigation**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Corps of Engineers,Waterway Experiment Station,3903 Halls Ferry Road,Vicksburg,MS,39180**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**79**	

PREFACE

The model study of plans to supplement present harbor facilities at Memphis, Tennessee, was authorized by the President, Mississippi River Commission, CE, in second wrapper indorsement to Waterways Experiment Station letter dated 2 October 1946, subject: "Proposed Model Study, Presidents Island, Mississippi River." The tests were conducted by the Hydraulics Division of the Waterways Experiment Station, during the period August 1947 to May 1948, under the supervision of Messrs. G. B. Fenwick and E. B. Lipscomb, assisted by Messrs. W. L. McInnis and W. E. Marsalis.

Prior to undertaking the model study, personnel of the Waterways Experiment Station made an inspection trip to the site of the problem area. At the conclusion of this trip, the type of model to be constructed and the operational procedure to be followed were determined in conferences of representatives of the Mississippi River Commission, the Memphis District, and the Waterways Experiment Station. Details of the original design plan and the prototype data necessary for construction of the model were furnished by the Memphis District. Revisions to the original plan were furnished by the Mississippi River Commission. Preliminary results of the tests of each plan were furnished the Mississippi River Commission at the conclusion of each test phase. The data presented in this memorandum supersede all preliminary results previously reported.

CONTENTS

SUMMARY

Tests to determine the feasibility of a plan to supplement present harbor facilities at Memphis, Tennessee, were conducted on a model built to a horizontal scale of 1:600 and a vertical scale of 1:150 and so constructed that it could be operated either as a fixed-bed model or as a movable-bed model. Of particular interest in the study was the determination of effects the various proposed plans of improvement would have on flood heights and channel configurations.

Results of the fixed-bed model tests, which were conducted with 1937 channel conditions installed, indicated that: (a) installation of the plan as originally designed would increase flood heights at Memphis approximately 3.2 ft* for the 1937 flood and 3.1 ft for the project flood; (b) omission of the left-bank chute levee from the plan would reduce the crest stages of the 1937 and project floods at Memphis as shown in (a) above by about 0.3 ft and 0.1 ft, respectively; and (c) the lower end of the industrial fill and the northwest corner of the left-bank chute levee would be subjected to strong current attack.

Results of the movable-bed model tests indicated that: (a) the stabilization works at the head of Presidents Island in the original design would be subjected to strong current attack and would increase

---

* Actually, flood heights at Memphis would not be increased above those observed during the 1937 prototype flood. The construction of Jackson Point, Sunflower, and Hardin Point Cutoffs in 1941 and 1942 has resulted in an increased channel capacity which has now developed to an extent that a crest volume of flood flow passes Memphis at a stage about 3-1/2 ft or more below that observed in 1937.

shoaling on the bar opposite the Engineer Depot; (b) modifications to the original plan would reduce the current attack and shoaling mentioned in (a); and (c) installation of either the original or modified plan would subject the Bauxippi revetment to increased current attack (maximum channel velocities increased 50 per cent) and would increase shoaling in the mouth of Tennessee Chute.

C O P Y

SUBJECT: Request for Copies of Technical Memorandum No. 2-320 (Basic ltr undtd)

WESDR 1st Ind

Waterways Experiment Station, CE, Vicksburg, Miss., 25 JUN 1954

TO: The President, MRC, CE, US Army, Vicksburg, Mississippi

W.L.B.

LMVCS 461(Chief of Engineers) 2d Ind

1 JUL 1954

Office, Pres, MRC, CE, Vicksburg, Miss.

TO: CofEngrs
ATTENTION: ENGHL

1. Two (2) copies of Technical Memorandum No. 2-320, being "Model Investigation, Memphis Harbor, Mississippi River," conducted for the President, Mississippi River Commission, by the Waterways Experiment Station December 1950, are herewith inclosed.

2. Only a limited number of copies of the report were published and distribution has been for official use only in this office and the Memphis District.

FOR THE PRESIDENT:

Incls
T.M. 2-320 (in dup).

C. F. MITCHIM
Colonel, CE
Secretary, Mississippi River Commission

MEMPHIS HARBOR
MISSISSIPPI RIVER

Model Investigation

PART I: INTRODUCTION

1. Memphis, Tennessee, is located on the bluff left bank of the Mississippi River at the mouth of Wolf River, which emerges from the hills at the northern limits of Memphis and flows southerly to its confluence with the Mississippi on the Memphis waterfront (mile 732, see plate 1). Approximately 2 mi below the confluence of the two rivers, the channel of the Mississippi is divided by a large body of land known as Presidents Island. The main channel of the river flows westward around the island; that portion of the river flowing eastward around the island is called Tennessee Chute. The flood plain of the Mississippi River at Memphis is bounded by the high natural bluffs on the east and by the St. Francis Levee system on the west.

2. The channel of the Mississippi River in the vicinity of Memphis has an average width of 5000 ft and average depth of 35 ft at bankfull stage. Low- and high-water slopes per mile are 0.3 ft and 0.4 ft, and minimum and maximum recorded discharges are 82,000 and 2,020,000 cfs, respectively. At the Corps of Engineers Memphis gage (zero, 184.2 mGl), stages since 1900 have ranged between -1.1 and 50.4 ft. High stages, generally inundating lands from the bluff on the east to the protection levee on the west, usually obtain in winter and spring and low stages prevail in the fall.

3. For many years Tennessee Chute rather than the west fork was

the main channel of the river at Presidents Island, and up to 1904 it carried the larger part of the low-water flow. At present, top bank widths of this chute vary from one mile at the head to one-half mile at the mouth. The least cross-sectional area at mean low water (1944 survey) is 2600 sq ft compared to 42,000 sq ft in the main channel west of the island. About 6 per cent of low and 30 per cent of bankfull flow passes through the chute.

4. Currently the harbor of the city of Memphis comprises the upper two miles of Tennessee Chute, two miles of the Mississippi River upstream therefrom, and the lower three miles of Wolf River. It has become apparent that, although this area is adequate for existing terminals, additional terminal space, free from the hazards of high flood velocities, is required to meet the needs of expanding commerce. As a result of this foreseen need, a project known as the "Tennessee Chute Plan" to supplement harbor facilities has been proposed and approved for construction.

5. The "Tennessee Chute Plan" provides for an off-river harbor with provisions for adequate terminal and industrial sites having both flood protection and desired access to water transportation. Principal features of the plan, with tentative dimensions, are as follows (plate 1):

a. Closure dam at head of Tennessee Chute (crown elev 245 ft mGl, width 100 ft, side slopes 1 on 8) with revetment, bank paving, and sodding as required, and access approach to east abutment.

b. A 2000-ft-wide industrial fill, above flood stage, extending for approximately four miles down the east side of Presidents Island along the west bank of Tennessee Chute and connected to the east bank by a causeway across the dam.

c. A dredged harbor channel with minimum dimensions 12 by 500 ft, contiguous to the fill, and corrective dredging in the main river.

d. A dredged entrance channel, 12 by 300 ft, in lower Tennessee Chute from the Mississippi River to Nonconnah Creek.

e. Protective works at the head of Presidents Island comprising pile dikes, batture fills and revetted banks to protect the closure dam and industrial fill from excessive current attack.

f. A levee along the left bank of the chute and river about 11 miles long, extending from the hills south of Cypress Creek to high ground in the vicinity of North Horn Lake.

g. Extension of existing sanitary sewer from its outfall near Nonconnah Creek to the Mississippi River at the lower end of Tennessee Chute.

6. Since the installation of such a plan as described above would completely close Tennessee Chute, thereby forcing all flow through the main channel of the river, engineers concerned with the project were confronted by several problems. It was anticipated that if a major flood were to occur immediately after completion of the project, flood stages at and upstream from Memphis would be considerably increased; current velocities in the main channel would be greater, thereby subjecting the revetted bank to heavy current attack; the channel would be deepened by scouring, and the scoured material might cause shoaling at critical points. It was believed that, if the regimen of the river were allowed to readjust itself after the completion of the closure project and before the occurrence of a major flood, the cross section of the main channel would be increased by scouring to the extent that crest water-surface elevations of such a flood would not be appreciably greater than those which would result under present conditions. It was also thought that revisions to the proposed plan might be found which would increase its over-all efficiency and lower costs.

7. The multiplicity of the questions raised and the interrelation

of controlling factors presented a complex problem. In view of the obvious difficulties confronting an attempt to determine answers to all the questions by normal analysis, and considering the large expenditures necessary for such a project, a model study of the problem was deemed appropriate.

PART II: THE MODEL

8. The model was of the type that could be operated alternately as a fixed-bed model and as a movable-bed model. The fixed portion was molded in concrete and the movable bed was molded in granular coal graded to grain-size specifications. The basic criteria for design of a model of this type are that it accurately reproduce corresponding prototype stage-discharge relationships when operating as a fixed-bed model and that it correctly simulate bed movement and changes in channel configuration when operating as a movable-bed model. Considering these criteria, the linear-scale ratios selected for the model were 1:600 horizontally and 1:150 vertically.

9. Reproduced in the model were approximately 23.5 miles of the Mississippi River from Redman Point to Cow Island and all the overbank area subject to overflow (plate 2 shows the model limits). It was necessary to reproduce channel and overbank areas for a considerable distance above and below the problem area at Presidents Island in order to simulate natural flow conditions and to include control gage locations for which adequate prototype data were available. Overbank detail was taken from the 1939 topographic survey. Locations and alignments of levees, lakes, and fills for highways and railroads were taken from the 1946 hydrographic survey. The revetted section of the Memphis front was molded to the 1933 Memphis front annual resurvey. Levees and bridges were built to 1937 conditions and to the latest available grades. The channel of the Mississippi River was molded to the 1937 hydrographic survey for the fixed-bed tests. Different surveys were used to mold the movable bed and will be

discussed in their proper sequence in the testing procedure.

10. The model was 183 ft long and 66 ft wide. Its effective area was 6670 sq ft, equivalent to approximately 86 sq mi of prototype area. For both fixed-bed and movable-bed model tests, channels were molded to sheet-metal templets which were cut to agree with the prototype survey and set to grade before molding. Templets and all surface details were located on the model by means of a modified polyconic grid system set up during construction.

11. Model appurtenances were of conventional types and require no detailed description. Inflows were measured by a right-angle, V-notch weir. Water-surface elevations were taken by means of fixed and portable point gages. Tailwater elevations were controlled by a movable tailgate. During the course of the testing procedure it was found that water temperatures below 70° F caused excessive riffling of the movable bed. To overcome this difficulty, the water supply was heated to the proper temperature by means of steam-heated pipe coils installed in the supply sump. Current velocities were measured by means of a miniature propeller-type current meter.

12. Operation of the model was conducted in two separate phases: (a) fixed-bed tests with the entire model molded in concrete and flows at constant discharge; and (b) movable-bed tests with the overbank areas molded in concrete, the channel molded in granular coal, and flows at varying discharge. The two phases required separate verifications and different operational procedures, and therefore will be considered separately in the following discussions.

PART III: NARRATIVE OF FIXED-BED TESTS

13. The fixed-bed phase of the model investigation of Memphis Harbor was concerned primarily with determination of effects on flood flows of the installation of the improvement plan. Accordingly, before the fixed-bed tests were undertaken it was necessary to insure that the model stage-discharge relationships agreed closely with corresponding prototype relationships observed during the occurrence of a major flood. This required careful adjustment of model channel and overbank roughness. A description of this adjustment is presented below.

Fixed-bed Adjustment

14. Adjustment of the model preparatory to conducting the fixed-bed tests was accomplished in two steps, the first step being the adjustment of channel roughness and the second step being the adjustment of overbank roughness. The channel roughness was adjusted to provide an accurate reproduction of the prototype bankfull flow of May 1937 and the overbank roughness was then adjusted until the flood crest of February 1937 was reproduced. Bankfull and crest prototype discharges reproduced were 1,066,000 cfs and 2,020,000 cfs, respectively.

15. Adjustment of channel roughness was obtained by introducing the proper discharge into the model, holding the tailwater elevation to the corresponding prototype elevation for that flow, and adjusting the channel roughness by trial and error until water-surface elevations at all model gaging stations corresponded to prototype elevations for the flow used. Overbank adjustment was obtained in like manner, but by using

the crest flood flow instead of the bankfull flow. Photograph 1 shows the three types of roughness used in the adjustment process. These types were: (a) a thin layer of pulled stucco over the entire overbank area, (b) fist-size stones cemented in place where additional overbank roughness was needed, and (c) strips of 1/4-in.-mesh hardware cloth, crimped and laid flat in the channel.

16. During adjustment of the model, it was found practicable to change the discharge scale from the theoretical value of 1:1,102,000 to 1:1,000,000, in order to reduce the extent of model roughness needed for the proper adjustment of model stages. It was felt that the amount of this change in discharge scale was not sufficient to compromise the test results and that the reduction in amount of roughness required would considerably facilitate observation of overbank current directions.

17. Results of the adjustment are shown on plate 3 in the form of bankfull and crest water-surface profiles for both model and prototype. The data shown on plate 3 also are presented in tabular form in table 1. These data show that model reproduction of prototype elevations was extremely close, the average variation between the two profiles being about 0.1 ft.

Testing Procedure

18. The improvement plan for Memphis Harbor was subjected to study under conditions of two major floods, the 1937 flood and the project flood. For the 1937-flood tests a constant discharge of 2,020,000 cfs was introduced into the model and for the project flood a constant discharge of 2,450,000 cfs was used. In each of these test floods, tailwater

elevations were controlled to the proper elevation as determined from a stage-discharge curve for H.W. gage 139.

19. The same general procedure was followed in the conduct of tests of both the 1937 and project floods. In each case, the test flood was first reproduced in the model without the improvement plan installed in order to establish a basis of comparison for the analysis of results obtained in later tests made under the same conditions of flow with the plan or any modifications thereof placed in the model. By a direct comparison of the resulting data, the effects of installing the plan or any desired modifications could be immediately determined for the test flood concerned.

Tests of 1937 Flood

Base test 1

20. Base test 1 was a study of existing (1937) prototype conditions subjected to the 1937 flood. The purpose of the test was to obtain data to be used as a basis for the determination of the effects of the improvement plan.

21. Observations of water-surface elevations for the test of existing conditions were made at all Mississippi River gages shown on plate 2. The results of these observations are presented as water-surface profiles on plate 4 and in tabular form in table 2. Flow conditions for base test 1 were recorded by photographing floating confetti (photograph 2).

Test 1 -- Plan 1

22. The purpose of test 1 was to determine the effects the

improvement plan (Plan 1) would have on crest water-surface elevations of the 1937 flood. All elements of the improvement plan for this test are shown on plate 8, except the left-bank chute levee which is shown on plate 1.

23. A comparison of the results of base test 1 and test 1 presented on plate 4 and in table 2 shows that installation of Plan 1 would result in the crest of the 1937 flood being increased 3.2 ft at the Memphis (CE) gage and 2.4 ft at model gage No. 1. Photograph 3 shows, by means of confetti, the surface currents observed in test 1. This photograph reveals the existence of a large eddy directly upstream from the closure dam and another in the chute channel at the lower end of the industrial fill. Currents impinged against the industrial fill just above its downstream end, and there was turbulent flow around the end of the fill. The outermost corner of the proposed left bank chute levee was also subjected to attack by currents sweeping around the end of the fill.

24. Attention is called to the fact that the increase in crest flood stages noted above would be true only for a 1937 flood repeated under 1937 conditions, and not for a flood of the same magnitude which might occur under present conditions. Operation of Jackson Point, Sunflower, and Hardin Point Cutoffs since 1941 and 1942 has resulted in a shortening of the river and an increased channel capacity. Channel capacity has now developed to an extent that a crest volume of flood flow passes Memphis at a stage about 3-1/2 ft or more below that which would have been occasioned in 1937.

Test 2 -- Plan 1

25. The purpose of test 2 was to determine the effects on 1937

flood stages of omitting the left-bank chute levee from Plan 1. Model conditions and operating technique for test 2 were the same as for test 1, except for the omission of this levee.

26. Test results (table 2 and plate 4) show that omission of this levee resulted in an appreciable lowering of water-surface elevations throughout the Memphis reach with a lowering of 0.3 ft noted at the Memphis (CE) gage. Photograph 4 shows surface currents observed in test 2. Comparison of this photograph with the similar photograph of test 1 conditions indicates that omission of the left-bank chute levee would not affect the impingement of flow against the lower end of the industrial fill but would prevent the development of the eddy in the lower chute channel.

Tests of Project Flood

Base test 2

27. Base test 2 was a study of existing (1937) prototype conditions subjected to the project flood. Except for the test flood used, model operating conditions and technique were identical for base tests 1 and 2.

28. Water-surface elevations observed in base test 2 at all Mississippi River gages shown on plate 2 are presented in table 2 and on plate 4. Surface currents for the project-flood base test are shown on photograph 5. A comparison of photographs 2 and 5 indicates that, in general, project-flood current directions were the same as those observed for the 1937 flood. It will be noted, however, that flows of project-flood magnitude resulted in a downstream movement of the large eddy observed in front of the Engineer Depot in the 1937-flood base test.

Test 3 -- Plan 1

29. The purpose of test 3 was to determine the effects that installation of the original improvement plan (Plan 1) would have on water-surface elevations and current directions of the project flood. Model conditions were identical to those of test 1 with the complete plan in place according to design location and grades (plates 1 and 8).

30. Water-surface elevations observed in test 3 are presented in table 2 and plate 4. Comparison of these data with similar observations for base test 2 indicates that installation of Plan 1 would increase project flood stages at Memphis (CE) gage about 3.1 ft, which is practically the same as the 3.2-ft increase in 1937 flood crest stages produced under identical conditions. The interpretation of the increase in flood heights observed in similar tests of 1937 flood (see paragraph 24) also applies to result of project-flood test. Photograph 6 shows surface currents resulting from Plan 1. Comparison of this photograph with photograph 3 discloses that flow conditions for both floods were practically the same, with strong current attack at the downstream end of the industrial fill and at the outermost corner of the proposed left-bank chute levee.

Test 4 -- Plan 1

31. Test 4 was conducted for the purpose of determining the effects on project-flood flows of omitting the left-bank chute levee from Plan 1. Except for the omission of this levee, test 4 was identical to test 3.

32. Water-surface elevations obtained during test 4 are presented in table 2 and on plate 4. These observations compared with similar results of test 3 indicate that omission of the left-bank chute levee from

Plan 1 resulted in a lowering of water-surface elevations amounting to 0.3 ft at the Memphis (USWB) gage and 0.1 ft at the Memphis (CE) gage. Current directions for the test are illustrated in photograph 7. Comparison of photographs 6 and 7 shows that omission of the levee would have negligible effect upon current attack along the face of the industrial fill and upon eddy development above the closure dam.

PART IV: NARRATIVE OF MOVABLE-BED TESTS

Movable-bed Adjustment

33. Upon completion of the fixed-bed tests described above, the concrete channel of the Mississippi River between mile 728.5 AHP and 721.5 AHP was replaced with a movable bed of granular coal and adjustment of the movable bed was initiated. The granular coal bed material was screened and only that which passed through a 1/8-in. mesh and was retained on a 1/28-in. mesh was used. It was washed to remove all foreign matter and any coal dust that might have adhered to the larger particles. The coal used had a specific gravity of 1.30.

34. Adjustment of movable-bed models is essentially a trial-and-error procedure with empirical values assigned to various scale relationships. Prior to each trial-adjustment test for this study, the movable bed was molded to conform to the 1935 prototype hydrographic survey. A time scale of eight hours in the model to one year in the prototype was used at the beginning of model operation. Inflows based upon a step hydrograph plotted from recorded prototype stages for the period November 1935 to September 1937 were introduced in the model. This period was chosen because it included both extreme low-water and extreme high-water flows and because a complete prototype hydrographic survey was made just prior to and immediately following that period. The hydrograph used is shown on plate 5. The model inflow discharges were adjusted to produce the proper stages at the Memphis (CE) gage which was used as the upper control gage. Tailwater elevations at H.W. gage 139, the lower control gage, were held to values taken from a stage relationship curve plotted

from recorded prototype data. Bed material was introduced just above the movable-bed section to compensate for material being moved out of that area. Prototype dredging was simulated by manual removal and redeposition of material in accordance with furnished dredging plans and surveys. Small gravel was used to prevent excessive and unnatural scouring at sections of transition from fixed to movable bed and to mattress the ends of dikes where a tendency toward excessive scouring was evident. The locations of such gravel-revetted areas are shown on plates 15-22. Water-surface elevations were taken at all gaging points for each successive stage of the step hydrograph. After completion of each trial-adjustment test, the movable bed was cross-sectioned and the results were plotted for comparison with the September 1937 prototype hydrographic survey and with the preceding tests. Results of the comparison were analyzed and adjustments were made in the variable components of rate of introducing bed material, grain size of bed material, time scale, discharge scale, slope of water-surface profiles and slope of bed profile. This trial-and-error procedure was repeated until thirteen successive tests had been made.

35. Before a satisfactory adjustment of the movable bed had been obtained, the adjustment procedure was interrupted by order of the President, Mississippi River Commission, to allow a series of special, preliminary tests to be conducted on the model. The purpose of these special tests was to give preliminary, qualitative indications relative to the effects of the Tennessee Chute closure upon: (a) the stabilization structures planned for construction at the head of Presidents Island; (b) the increase in velocities at critical sections in the main channel around

Presidents Island; and (c) changes in configuration of bed of the main channel.

36. During the process of the trial-adjustment tests, changes were made in most of the variable scale relationships. The granular coal bed material was resized to pass through a 1/8-in. mesh and be retained on a 1/16-in. mesh. This resulted in a mean grain diameter of 1.10 mm. The time scale used for the last trial-adjustment test and for all succeeding tests was 20 hours equal to one prototype year for all stages of 16 ft and above on the Memphis (CE) gage, and 14 hours equal to one prototype year for all stages below 16 ft. The water-surface profiles were adjusted to give slopes of 0.000319 on all stages of 16 ft and above, and 0.000353 on all stages below 16 ft. This resulted in increased slopes for low stages and reduced slopes for high stages. No changes were made in the bed slope.

Tests of 1937 Flood

Base test 3

37. The results of the last trial-adjustment test were used as a basis of comparison for the succeeding 1937 flood tests and will be referred to hereinafter as base test 3. Plates 14 and 15 afford a comparison of the channel configuration obtained for base test 3 and that obtained by the September 1937 prototype hydrographic survey. Water-surface elevations and main channel current velocities are shown in tables 3 and 11, respectively. Locations of velocity ranges are shown on plate 2.

Test 5 -- Plan 2

38. General model conditions for test 5 were the same as for base

test 3. Plan 2, as shown on plate 9, was installed in the model (see photograph 8), the left-bank chute levee being omitted entirely. Inflows and outflows were controlled by using the same weir heads and tailgate settings obtained for base test 3. Dredging was simulated and bed material was introduced according to the procedures established in base test 3.

39. Plate 16 shows channel bed configurations resulting from the test while water-surface elevations are presented in table 4 and on plate 6. Table 12 lists current velocities obtained at critical points in the main channel. Comparison of the results of test 5 with the results of base test 3 indicates that: (a) the crest water-surface elevation was raised 3.0 ft at the Memphis (CE) gage; (b) the bar opposite the Engineer Depot was increased in height; (c) considerable scouring occurred behind the lower end of the Presidents Island revetment; (d) heavy scouring occurred along the Bauxippi revetment, resulting in several deep holes; (e) appreciable shoaling occurred in the mouth of Tennessee Chute; (f) a high ridge developed across the upper end of Tennessee Chute just above the closure dam; (g) maximum current velocities were increased approximately 50 per cent; and (h) the protective structures at the head of Presidents Island were subjected to heavy current attack.

Test 6 -- Plan 3

40. Observations made during test 5 indicated that current attack on the protective structures at the head of Presidents Island could be decreased by moving the face of the revetment back to the 1935 top bank line on the lower end of the revetment, removing all old dikes in the

vicinity that extended riverward of the new revetment alignment, reducing the length of the new dikes to conform with the new alignment, and adding two sections of wing and spur dikes to the proposed system. Accordingly, preparations were made to test such a revised plan (Plan 3) in the model.

41. General model conditions and operating technique for test 6 were the same as for test 5. Plan 3 as shown on plate 10 was installed in the model; the left-bank chute levee was omitted entirely. The purpose of the test was to determine the effects of the revised protective structure plan upon flows of the 1937 flood.

42. Plate 17 shows channel bed configurations obtained for the test. Water-surface elevations are presented in table 5 and on plate 6 while table 13 gives current velocities observed at critical points in the main channel. Comparison of these data with results of test 5 indicates that the revised plan reduced scouring around the end of the Presidents Island revetment and increased maximum velocities along the Bauxippi revetment. Further comparison of test 6 data with results of test 5 indicated that stage-height changes were small and that the effects of the plan upon bar heights and the general scour pattern were negligible.

Test 7 -- Plan 4

43. Observations made during test 6 indicated that further realignment of the protective system and revision to the dike plan would prove beneficial. In all plans tested so far, the general alignment of the protective works had been held out into the channel in an attempt to force the current across the bar in front of the Engineer Depot and thereby maintain an access channel to the Depot. Since previous tests had proved

the infeasibility of this idea, it was decided for test 7 to move the closure dam 600 ft back into the chute, move the upper end of the Presidents Island revetment back to a better alignment with the 1935 top bank, and decrease the lengths and number of dikes in the protective system in order to obtain a smoother flow pattern in the bend at the head of Presidents Island. It had been foreseen that considerable bank erosion would occur directly below the Presidents Island revetment and that such erosion might have considerable effect upon channel and bar configurations below that point. In order to simulate such changes, the left bank of the model just below the Presidents Island revetment was molded in an erodible material to reproduce the estimated bank erosion at that point. The model was then prepared to test the plan (Plan 4) as outlined above.

44. General model conditions and operating procedure for test 7 were the same as for test 6. Plan 4, as shown on plate 11, was installed in the model; the left-bank chute levee was omitted entirely. The purpose of the test was to determine the effects of the revised closure plan upon the flows of the 1937 flood with particular attention being given to flow lines around the bend at the head of Presidents Island.

45. Channel configurations obtained for this test are shown on plate 18. Water-surface elevations are presented in table 6 and on plate 6, while table 14 gives the current velocities obtained at critical points in the main channel. Comparison of these data with the results of test 6 indicates that: (a) crest stage heights were lowered 0.4 ft at Memphis (CE) gage; (b) the bar opposite the Engineer Depot was reduced in height; (c) scour around the lower end of Presidents Island revetment was reduced but was still great enough to endanger the revetment; and (d) maximum

velocities in Bauxippi bend were reduced slightly.

Test 8 -- Plan 5

46. Observations of flow patterns during test 7 in the bend above Presidents Island and along the upper end of the industrial fill indicated that further setbacks in the alignment of the protective works would be advisable. Accordingly, it was decided to set back the upper end of the industrial fill 1000 ft from the original alignment (Plan 1); allow the landside end of the closure dam to remain as in Plan 1; reduce the number of dikes to three and reduce their lengths; and move the Presidents Island revetment alignment back approximately 600 ft with the lower end converging with the 1947 top bank line. The plan thus evolved was investigated in test 8 as Plan 5.

47. General model conditions for test 8 were the same as for test 7. Plan 5, as shown on plate 12, was installed in the model. Model operating procedure was the same as for test 7.

48. Channel configurations obtained for this test are shown on plate 19. Water-surface elevations are presented in table 7 and on plate 6, while table 15 shows current velocities obtained at critical points in the main channel. Comparison of these data with the results of test 7 indicates the following effects of Plan 5: (a) the crest stage at Memphis (CE) gage was reduced 0.3 ft; (b) there was no scour around the lower end of Presidents Island revetment; (c) the left bank below the Presidents Island revetment eroded only enough to bring it into smooth alignment with the revetment face; (d) current velocities were increased slightly in Bauxippi bend.

Test 9 -- Plan 6

49. In general, Plan 5 was deemed the best of all plans tested. However, it was believed that further improvements could be made by turning the lower end of the Presidents Island revetment normal to the bank alignment and rounding the face. It was believed that such revision would offer added protection from scour to the revetment at that point. This plan (Plan 6) was investigated in test 9.

50. With the exception of the revision mentioned above, model conditions for test 9 were identical to those for test 8. The elements of Plan 6 are shown on plate 13. Model operating procedure was the same as for test 8.

51. Channel configurations obtained for the test are shown on plate 20. Water-surface elevations are presented in table 8 and on plate 6, while table 16 shows current velocities obtained at critical points in the main channel. It is believed that the change in plan between test 8 and test 9 was of such nature that its effects on flow conditions and channel configurations would be entirely local and of small magnitude. Although a comparison of the results of tests 8 and 9 show slight differences in water-surface elevation and scour and fill, it is believed that these differences are within the limits of the model accuracy and therefore are probably not a result of the change in plan between the two tests.

52. Upon completion of test 9 it was decided to conduct a test of Plan 6 with the movable bed molded to the latest available survey and using project-flood flows. To accomplish this, it was first necessary to conduct another base test.

Tests of Project Flood

Base test 4

53. For this test, the movable bed was molded to conform with the November 1947 prototype hydrographic survey. The fixed concrete bank lines were remolded to conform with the latest top bank surveys. The project flood with a crest of 2,450,000 cfs at Memphis was reproduced. Plate 5 shows the control hydrograph used which was plotted from data furnished by the Mississippi River Commission. Tailwater elevations were held to a curve plotted from furnished data. Water-surface slopes for the various stages were made to conform with slopes for corresponding 1937 stages (see paragraph 24 and 36). Bed material was introduced just above the movable-bed section at a rate that would offset scour in that vicinity. No dredging was simulated. The erodible-bank section on Presidents Island was molded to the 1947 top bank survey. The purpose of the test was to provide a basis of comparison to be used in determining the effects of the final revised plan (Plan 6) upon project flood flows.

54. Channel bed configurations obtained for this test are shown on plate 21. Water-surface elevations are presented in tables 9 and 10 and on plates 6 and 7. Current velocities obtained at critical points in the main channel are presented in table 17.

Test 10 -- Plan 6

55. General model conditions for test 10 were the same as for base test 4. The Tennessee Chute closure and protective works were installed exactly as in test 9 (plate 13). In addition, the left-bank chute levee was in place. The erodible-bank section at the head of Presidents Island

was molded to the 1947 top bank survey. Photograph 9 is a view of the plan as it was installed in the model. Inflows and outflows were controlled by using the same weir heads and tailgate settings used for base test 4. Bed material was introduced in accordance with the procedures established in base test 4. No dredging was simulated.

56. Channel configurations obtained for the test are shown on plate 22. Water-surface elevations are given in tables 9 and 10 and on plates 6 and 7. Current velocities observed at critical points along the main channel are presented in table 17. Comparison of these data with results of base test 4 indicates the following effects of Plan 6: (a) the crest stage at Memphis (CE) gage was increased 3.3 ft; (b) the height of the bar opposite the Engineer Depot was increased; (c) heavy scouring occurred around the lower end of the Presidents Island revetment; (d) a point bar developed along the left bank below the end of the Presidents Island revetment; (e) heavy scouring occurred in Bauxippi bend; (f) shoaling in the mouth of Tennessee Chute was increased; and (g) velocities in the channel around Presidents Island were increased approximately 50 per cent.

57. Upon completion of the tests mentioned above, instructions were received from the Office of the President, Mississippi River Commission, to the effect that sufficient information relative to the design of the Memphis Harbor plan had been obtained and consequently further testing would be unnecessary.

PART V: DISCUSSION OF RESULTS

58. It is believed that the fixed-bed phase of the study of plans to supplement harbor facilities at Memphis was successful in accomplishing the specific purpose for which it had been undertaken, i.e., determination of effects of the improvement plan on flood heights. The results of the fixed-bed tests may be accepted as being accurate indications of stages which will occur in the river under similar discharge and channel-configuration conditions. However, in view of the limitations imposed on the movable-bed phase of the study by the decision to undertake these tests without having obtained a completely satisfactory adjustment of the movable-bed model, the results of the movable-bed studies should be considered as indicating only very general qualitative trends as to channel configurations and velocities to be expected after installation of the proposed harbor facilities.

59. The principal conclusions drawn from an analysis of the data obtained in the fixed-bed studies are as follows:

a. Installation of the complete Tennessee Chute plan would increase flood heights at Memphis (CE) gage approximately 3.2 ft for the 1937 flood and 3.1 ft for the project flood.

b. Omission of the left-bank chute levee would result in lowering crest flood heights at the Memphis (CE) gage from those in a above by 0.3 ft for the 1937 flood and 0.1 ft for the project flood.

c. The lower end of the industrial fill and the outermost corner of the left-bank chute levee would be subjected to considerable current attack.

60. The principal indications derived from an analysis of the data obtained in the movable-bed studies, it being understood that there

existed no positive assurance of model-to-prototype relationships, are as follows:

a. The revetment along the face of the stabilization works at the head of Presidents Island, as investigated in Plan 2, test 5, would be subjected to heavy current attack, and there would be increased shoaling on the bar opposite the Engineer Depot.

b. The revetment along the face of the stabilization works at the head of Presidents Island, as investigated in Plan 6, tests 9 and 10, would be subjected to less attack than a above and the amount of shoaling on the bar opposite the Engineer Depot would be reduced from that observed in test 5.

c. After the closure of Tennessee Chute, Bauxippi-Wyanoke revetment would be subjected to increased attack, maximum channel velocities being increased about 50 per cent. As a result of the increased velocities heavy channel scour along the Bauxippi-Wyanoke revetment should be expected after the closure of Tennessee Chute.

d. Installation of the closure works would result in increased shoaling in the lower end of Tennessee Chute and above the closure dam at the upper end.

Table 1

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Fixed-bed (Adjustment)

Gage	Elevation in Feet mGl					
	Bankfull Flow			Crest Flow		
	Proto	Model	Diff	Proto	Model	Diff
Model gage No. 1	221.1	221.1	0.0	237.7	237.8	+0.1
L.L. 220.7-L	219.5	219.5	0.0	236.4	236.4	0.0
Model gage No. 2	219.3	219.3	0.0	236.0	236.0	0.0
Memphis (CE)	217.8	218.0	+0.2	234.6	234.6	0.0
Memphis (USWB)	216.9	217.2	+0.3	232.9	232.5	-0.4
H.W. 141	215.6	215.6	0.0	231.6	231.6	0.0
L.W. 235.0-R	213.9	213.9	0.0	230.4	230.4	0.0
L.W. 238.2-L	212.9	213.0	+0.1	229.2	229.2	0.0
H.W. 139	212.0	212.0	0.0	228.3	228.3	0.0
Tennessee Chute	214.5	214.5	0.0	230.8	231.0	+0.2
Model gage No. 3	213.6	213.6	0.0	230.0	230.0	0.0

Table 2

CREST WATER-SURFACE ELEVATIONS

Fixed-bed Tests

Gage	Elevation in Feet mGl					
	1937 Flood			Project Flood		
	Base Test 1	Test 1	Test 2	Base Test 2	Test 3	Test 4
Model gage No. 1	237.8	240.2	240.0	242.6	245.1	245.0
L.W. 220.7-L	236.4	239.0	238.5	241.2	243.8	243.5
Model gage No. 2	236.0	238.7	238.4	240.9	243.6	243.5
Memphis (CE)	234.6	237.8	237.5	239.6	242.7	242.6
Memphis (USWB)	232.5	235.8	235.5	237.0	240.9	240.6
H.W. 141	231.6	233.4	233.0	236.0	238.4	237.9
L.W. 235.0-R	230.4	230.7	230.3	234.9	235.5	235.1
L.W. 238.2-L	229.2	229.1	228.9	233.7	233.7	233.7
H.W. 139	228.3	228.3	228.3	233.1	233.0	232.8
Tennessee Chute	231.0	229.8	229.2	235.7	234.8	233.9
Model gage No. 3	230.0	229.8	229.1	234.6	234.6	233.7

Table 3

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Base Test 3

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	205.8	228.6	191.1	206.3	227.0	237.8	227.1	207.0
L.W. 220.7-L	202.8	226.8	188.9	203.6	225.3	236.1	225.3	204.5
Model gage No. 2	202.4	226.2	188.7	202.8	224.3	235.1	224.0	203.4
Memphis (CE)	200.3	223.7	186.8	201.2	222.0	233.6	221.9	202.1
Memphis (USWB)	199.8	222.3	186.6	200.9	220.5	231.3	220.8	201.9
H.W. 141	197.9	221.3	184.7	198.8	219.6	230.3	219.6	199.5
L.W. 235.0-R	196.5	220.7	184.4	198.0	219.3	230.0	218.9	198.8
L.W. 238.2-L	195.0	218.7	182.1	196.8	217.1	228.6	216.9	197.7
H.W. 139	194.6	218.3	180.6	195.6	216.3	228.0	216.3	196.5
Tennessee Chute	197.3	221.1	185.1	198.3	219.6	230.7	219.6	198.8
Model gage No. 3	196.4	219.9	-----	197.6	218.4	229.5	218.3	198.2

Table 4

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Test 5

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	207.0	233.4	192.8	208.2	230.0	240.0	230.7	207.8
L.W. 220.7-L	204.2	232.1	190.7	205.7	228.8	238.5	229.2	205.4
Model gage No. 2	203.9	231.6	190.5	205.1	228.0	237.9	228.5	204.8
Memphis (CE)	201.5	230.1	189.2	203.3	226.2	236.6	226.7	202.7
Memphis (USWB)	201.3	228.9	189.2	203.3	225.3	234.8	225.9	202.5
H.W. 141	199.2	226.7	188.6	201.6	223.1	233.0	223.8	201.3
L.W. 235.0-R	197.9	224.0	188.1	201.6	221.7	231.3	221.7	200.9
L.W. 238.2-L	196.2	220.7	185.4	198.3	218.6	228.6	218.7	199.5
H.W. 139	194.7	217.7	181.7	196.8	217.1	228.3	217.2	197.0
Tennessee Chute	196.5	221.3	186.5	198.8	219.3	229.5	220.2	199.8
Model gage No. 3	196.4	221.3	186.3	198.8	219.3	229.4	220.1	199.7

Table 5

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Test 6

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	207.0	233.0	193.4	208.4	229.5	240.0	230.9	208.0
L.W. 220.7-L	204.0	231.6	191.7	206.3	228.0	238.5	229.4	205.5
Model gage No. 2	203.7	231.0	191.6	205.5	227.4	238.2	228.9	204.9
Memphis (CE)	201.5	229.7	190.5	203.7	225.6	236.7	227.1	203.0
Memphis (USWB)	201.3	228.0	190.4	203.6	224.7	235.1	226.1	203.0
H.W. 141	199.4	225.8	189.8	201.9	222.6	233.3	224.3	201.8
L.W. 235.0-R	198.0	223.2	189.5	201.2	220.4	231.2	221.7	200.9
L.W. 238.2-L	195.9	220.8	187.5	198.6	218.1	228.9	219.5	199.7
H.W. 139	194.9	217.7	184.4	197.0	216.8	228.3	216.6	196.8
Tennessee Chute	196.5	221.6	188.6	199.8	218.9	229.5	220.5	199.8
Model gage No. 3	196.2	221.4	188.4	199.5	218.7	229.2	220.4	199.7

Table 6

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Test 7

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	207.0	232.2	193.1	207.8	229.1	240.0	230.3	207.8
L.W. 220.7-L	204.0	230.6	191.0	205.2	227.4	238.2	228.8	204.9
Model gage No. 2	203.7	230.0	190.8	204.5	226.8	237.8	228.0	204.0
Memphis (CE)	201.5	228.5	189.9	202.8	224.2	236.3	226.4	202.4
Memphis (USWB)	201.2	227.1	189.6	202.5	224.3	235.7	225.5	202.1
H.W. 141	199.8	225.8	188.3	201.3	223.2	233.4	224.0	201.2
L.W. 235.0-R	197.7	223.5	187.8	200.4	220.5	230.4	222.0	200.1
L.W. 238.2-L	196.1	220.2	185.7	198.0	218.1	228.8	219.8	198.8
H.W. 139	195.0	218.4	182.7	196.4	216.0	228.0	217.1	197.1
Tennessee Chute	196.7	221.3	187.1	199.1	218.7	229.5	220.5	199.1
Model gage No. 3	196.8	221.4	187.1	199.2	219.0	229.5	220.7	199.4

Table 7

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Test 8

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	207.6	232.4	193.7	208.4	229.1	239.7	230.4	207.9
L.W. 220.7-L	204.3	231.0	191.0	205.8	227.6	238.2	228.6	204.8
Model gage No. 2	203.4	230.0	190.8	204.8	226.7	237.5	227.7	203.7
Memphis (CE)	201.8	228.2	189.6	203.1	224.9	236.0	225.8	201.9
Memphis (USWB)	201.5	227.3	189.6	203.0	223.8	234.3	224.7	201.6
H.W. 141	199.8	225.5	188.6	201.5	221.9	232.7	223.1	200.1
L.W. 235.0-R	197.6	223.8	188.6	200.6	220.8	230.7	221.0	199.8
L.W. 238.2-L	196.4	220.4	187.1	198.8	218.3	229.1	219.9	198.6
H.W. 139	195.0	218.3	184.4	196.7	216.6	228.2	216.9	196.8
Tennessee Chute	197.0	221.7	187.7	199.2	218.9	229.5	220.5	198.6
Model gage No. 3	196.7	221.4	187.4	198.9	218.9	229.2	220.4	198.6

Table 8

WATER-SURFACE ELEVATIONS -- 1937 FLOOD

Movable-bed Tests
Test 9

Gage	Elevation in Feet mGl							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Model gage No. 1	207.5	232.4	193.4	208.2	229.4	239.9	230.4	208.5
L.W. 220.7-L	204.5	230.3	190.4	205.1	227.6	238.1	228.8	205.2
Model gage No. 2	203.3	229.8	190.4	204.5	226.8	237.6	228.2	204.5
Memphis (CE)	201.8	228.6	189.5	202.8	225.3	236.9	227.0	203.0
Memphis (USWB)	200.9	226.8	189.2	202.4	223.8	234.5	225.2	202.2
H.W. 141	199.2	225.5	188.4	201.2	222.5	233.1	223.7	200.9
L.W. 235.0-R	198.0	223.8	188.1	200.1	220.4	231.8	222.5	200.6
L.W. 238.2-L	196.1	220.7	186.6	198.3	218.3	229.5	219.8	199.2
H.W. 139	195.0	217.8	182.6	196.8	216.8	228.5	217.5	197.0
Tennessee Chute	197.0	221.7	187.2	199.1	219.3	229.8	220.8	199.7
Model gage No. 3	196.8	221.6	187.1	199.1	219.3	229.7	220.8	199.7

Table 9

WATER-SURFACE ELEVATIONS -- PROJECT FLOOD

Movable-bed Tests

Gage	Elevation in Feet mGl					
	Base Test 4			Test 10		
	41.6-Ft Rising Stage	53.6-Ft Crest Stage	41.6-Ft Falling Stage	41.6-Ft Rising Stage	53.6-Ft Crest Stage	41.6-Ft Falling Stage
Model gage No. 1	228.9	240.0	228.9	232.8	243.8	234.3
L.W. 220.7-L	227.1	238.4	227.3	231.6	241.7	233.1
Model gage No. 2	226.5	238.1	226.7	230.9	241.4	232.5
Memphis (CE)	224.7	236.9	224.7	229.7	240.2	231.5
Memphis (USWB)	222.8	234.0	222.8	228.0	238.4	229.7
H.W. 141	222.2	233.6	222.3	226.4	236.7	227.4
L.W. 235.0-R	220.8	232.7	221.0	222.6	234.0	226.2
L.W. 238.2-L	219.8	231.3	219.8	219.8	231.0	222.0
H.W. 139	219.2	231.2	219.2	218.4	230.0	219.6
Tennessee Chute	222.3	234.0	221.9	220.7	232.7	223.7
Model gage No. 3	220.8	232.5	220.8	220.7	232.5	223.5

Table 10

CREST WATER-SURFACE ELEVATIONS ALONG LEVEES --
PROJECT FLOOD

Movable-bed Tests

Gage Location	Elevation in Feet mGl	
	Base Test 4	Test 10
Main Levee:		
L.M.P. 144/145	239.4	241.4
L.M.P. 145/146	239.1	241.5
L.M.P. 146/147	238.8	241.1
L.M.P. 147/148	238.8	241.4
L.M.P. 148/149	239.0	240.8
L.M.P. 149/150	238.1	240.5
L.M.P. 150/151	236.9	239.4
L.M.P. 151/152	234.6	237.1
L.M.P. 152/153	234.3	236.7
L.M.P. 153/154	234.2	236.1
L.M.P. 154/155	234.0	236.0
L.M.P. 155/156	234.0	236.4
L.M.P. 156/157	233.3	232.8
L.M.P. 157/158	233.1	233.1
L.M.P. 158/159	232.4	231.4
L.M.P. 159/160	231.5	230.2
Left Bank Chute Levee:		
1		232.7
2		232.7
3		232.7
4		232.4
5		230.5
6		230.2
Industrial Fill:		
1		238.7
1-A		232.7
2		237.3
2-A		232.7
3		235.8
3-A		232.7
4		234.6
4-A		232.7

Table 11

VELOCITY OBSERVATIONS -- 1937 FLOOD

Base Test 3

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	---	---	---	---	---	---	---	---
550	---	---	---	5.3	---	---	---	3.7
1150	6.1	2.1	---	---	3.0	---	---	5.0
1750	7.3	5.5	---	5.3	5.1	3.0	4.4	5.0
2350	7.3	7.1	6.7	5.3	4.7	3.8	4.1	4.8
2950	4.3	6.7	4.4	3.2	5.3	5.8	3.9	---
3550	---	6.3	---	---	4.7	7.3	5.1	2.8
4150	---	5.8	---	---	5.5	6.9	3.0	---
4750	---	---	---	---	---	7.6	---	---
Range 2								
350	6.1	4.7	2.3	5.1	4.9	4.0	6.4	4.1
650	5.3	6.7	2.9	6.0	7.6	6.6	7.2	5.0
1250	6.9	7.6	2.3	6.3	8.2	7.6	8.9	5.2
1850	4.7	8.2	---	5.3	8.2	8.1	8.3	---
2450	---	7.6	---	---	6.7	6.9	6.4	---
3050	---	---	---	---	---	---	---	---
3650	---	---	---	---	---	---	---	---
Range 3								
370	7.9	8.9	3.9	7.6	8.9	6.3	7.7	6.7
670	6.8	8.2	2.9	7.6	8.9	6.3	7.7	6.7
1270	5.5	7.1	---	5.7	8.2	5.8	7.7	5.8
1870	3.7	7.1	---	---	6.7	4.5	5.8	---
2470	---	6.7	---	---	5.5	3.4	5.0	---

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 12

VELOCITY OBSERVATIONS -- 1937 FLOOD

Test 5

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Feet Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	1.2	1.8	---	2.6	2.1	---	---	---
550	4.1	3.6	---	---	4.9	1.9	3.2	---
1150	4.1	6.3	---	---	6.0	4.6	4.8	---
1750	4.2	7.1	---	3.1	6.3	5.8	4.9	2.8
2350	4.4	8.2	8.6	3.0	7.1	7.6	6.4	3.0
2950	3.8	6.3	6.7	3.1	6.3	7.2	6.7	2.8
3550	---	4.9	9.3	---	3.1	7.2	3.2	3.0
4150	---	2.1	---	---	2.1	4.0	2.6	---
4750	---	---	---	---	---	---	---	---
Range 2								
350	5.5	6.7	1.7	3.3	9.6	7.6	8.3	3.4
650	6.1	12.1	1.3	3.3	10.7	11.0	8.9	2.8
1250	5.8	10.7	---	2.8	8.9	10.1	8.9	2.8
1850	3.7	9.6	---	2.5	8.9	10.1	7.7	2.3
2450	---	10.7	---	1.2	7.9	10.1	6.4	---
3050	---	---	---	---	---	---	---	---
3650	---	---	---	---	---	---	---	---
Range 3								
370	6.9	12.1	2.2	6.3	9.6	8.1	9.7	3.0
670	6.9	12.1	1.4	6.3	10.7	10.1	10.8	3.3
1270	3.1	10.7	---	5.7	9.6	9.4	9.7	3.0
1870	---	9.6	---	---	7.6	8.1	9.7	3.0
2470	---	6.7	---	1.4	6.7	7.2	8.9	2.8

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 13

VELOCITY OBSERVATIONS -- 1937 FLOOD

Test 6

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	---	1.5	---	2.8	1.4	1.8	2.1	---
550	2.7	3.1	---	3.9	5.3	2.4	5.1	---
1150	6.4	6.0	---	---	7.1	6.1	6.4	---
1750	6.4	6.0	---	2.3	7.1	7.6	7.1	3.3
2350	6.4	6.0	0.8	3.6	7.1	8.7	7.1	3.3
2950	5.5	5.8	1.7	3.8	8.2	8.7	7.1	3.7
3550	3.7	5.5	1.7	5.0	8.2	9.4	8.3	3.3
4150	---	4.6	---	---	---	3.2	4.1	---
4750	---	---	---	---	---	---	---	---
Range 2								
350	4.6	5.8	2.1	4.7	5.7	6.9	5.8	3.3
650	6.4	7.6	1.8	5.5	5.7	5.2	4.6	3.4
1250	6.4	9.6	---	2.6	9.6	9.4	7.2	4.0
1850	4.7	8.2	---	2.2	9.6	10.1	7.7	3.3
2450	---	8.9	---	---	8.9	13.8	7.2	---
3050	---	---	---	---	---	---	---	---
3650	---	---	---	---	---	---	---	---
Range 3								
370	7.3	12.1	1.7	5.3	8.9	12.3	8.3	4.1
670	6.8	11.3	1.3	5.3	12.1	12.3	8.9	4.5
1270	2.7	9.6	1.1	3.7	12.1	13.8	7.2	3.7
1870	---	7.6	---	2.6	9.6	11.0	7.7	3.7
2470	---	5.5	---	---	7.6	8.1	7.2	---

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 14

VELOCITY OBSERVATIONS -- 1937 FLOOD

Test 7

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	---	4.7	---	2.6	---	---	---	---
550	1.1	5.8	---	3.1	3.1	1.1	3.5	---
1150	6.1	7.1	---	---	6.3	3.8	5.4	---
1750	6.4	7.1	1.7	3.5	5.7	5.8	4.9	4.0
2350	6.8	5.8	1.9	3.5	4.1	6.3	5.4	3.5
2950	6.4	5.8	---	---	5.7	6.9	6.0	3.8
3550	---	8.2	1.9	3.9	5.1	8.1	5.4	3.7
4150	---	6.7	---	---	3.9	5.8	4.3	4.0
4750	---	---	---	---	---	3.6	1.9	---
Range 2								
350	4.4	5.8	2.3	2.7	3.6	3.2	3.9	3.3
650	5.8	8.2	2.8	4.2	7.1	4.0	7.2	3.3
1250	6.4	9.7	---	6.0	8.2	8.7	8.9	4.6
1850	4.9	9.6	---	3.5	8.2	9.4	8.9	4.1
2450	---	10.7	---	---	8.9	9.4	6.7	---
3050	---	9.6	---	---	7.1	9.4	---	---
3650	---	---	---	---	---	8.1	---	---
Range 3								
370	6.9	12.1	2.0	4.9	12.1	10.1	9.7	4.5
670	6.9	10.7	1.9	5.1	12.1	11.0	9.7	4.5
1270	3.9	12.1	1.2	4.9	12.1	11.0	8.9	4.5
1870	---	10.7	---	---	7.6	9.4	7.7	3.2
2470	---	7.6	---	---	5.7	4.3	2.8	---

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 15

VELOCITY OBSERVATIONS -- 1937 FLOOD

Test 8

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	1.0	---	---	3.8	1.3	---	1.4	1.3
550	2.1	3.9	---	---	5.1	2.4	4.5	---
1150	3.0	3.9	---	---	6.7	4.8	7.1	---
1750	5.8	5.8	0.9	3.0	6.7	5.4	6.7	5.2
2350	6.1	6.3	1.9	3.1	5.7	6.3	6.7	5.6
2950	5.8	6.0	---	---	5.1	5.6	5.8	5.4
3550	4.4	6.3	1.7	3.5	5.5	5.6	7.1	5.8
4150	3.3	5.1	---	3.7	4.7	7.2	5.5	5.0
4750	---	---	---	---	---	5.4	2.8	---
Range 2								
350	5.3	4.3	1.2	2.9	6.0	4.9	5.8	4.8
650	6.4	7.1	2.2	4.0	9.6	6.3	6.7	5.4
1250	6.8	10.7	0.9	4.5	12.1	11.0	8.9	4.7
1850	6.1	9.6	---	2.6	10.7	10.1	8.9	2.1
2450	4.4	8.2	---	---	7.1	10.1	8.9	---
3050	---	6.0	---	---	5.1	7.2	---	---
3650	---	---	---	---	---	---	---	---
Range 3								
370	7.3	12.1	2.0	6.7	10.7	9.4	9.7	6.3
670	6.8	12.1	2.0	6.7	10.7	12.3	9.7	5.0
1270	4.5	10.7	2.3	5.5	9.6	12.3	8.9	4.5
1870	2.7	8.2	---	4.1	7.6	11.0	7.1	4.6
2470	2.1	7.1	---	---	4.6	8.7	6.4	---

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 16

VELOCITY OBSERVATIONS -- 1937 FLOOD

Test 9

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec							
	16-Ft Stage Feb 1936	40-Ft Stage Apr 1936	2-Ft Stage Aug-Sept 1936	17-Ft Stage Nov 1936	38-Ft Stage Jan 1937	50-Ft Stage Feb 1937	38-Ft Stage Feb 1937	18-Ft Stage June 1937
Range 1								
250	---	1.4	---	3.5	2.4	---	6.4	---
550	2.5	3.5	---	4.1	6.3	1.4	3.4	---
1150	2.9	6.7	---	3.5	7.1	4.9	6.4	---
1750	5.8	8.2	---	---	7.6	7.2	7.7	3.3
2350	6.1	8.9	2.8	4.1	7.6	7.6	7.7	4.1
2950	5.5	8.9	3.2	3.7	6.7	9.4	7.7	5.4
3550	---	8.9	2.8	3.3	6.3	9.4	6.7	4.8
4150	2.5	6.3	---	2.9	4.6	8.1	6.4	3.9
4750	---	---	---	---	---	6.6	5.1	---
Range 2								
350	4.6	6.3	0.8	2.6	3.6	5.6	4.6	2.3
650	5.8	8.2	2.0	4.6	8.2	7.2	6.7	3.7
1250	6.4	10.7	1.6	6.3	9.6	10.1	9.7	9.4
1850	5.1	10.7	---	5.3	9.6	12.3	9.7	4.5
2450	---	9.6	---	---	7.6	12.3	8.9	---
3050	---	8.9	---	---	3.7	9.4	---	---
3650	---	---	---	---	---	---	---	---
Range 3								
370	7.3	10.7	2.1	6.3	9.7	12.3	9.7	5.0
670	6.4	10.7	2.1	6.0	9.7	12.3	9.7	4.6
1270	5.5	10.7	1.2	4.9	9.7	12.3	8.9	3.9
1870	---	8.9	---	4.1	8.9	**10.1**	8.3	3.3
2470	1.7	6.0	---	---	5.5	**7.6**	3.1	---

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Table 17

VELOCITY OBSERVATIONS -- PROJECT FLOOD

Distance From Nov 1947 Right Top Bank in Prototype Feet	Velocities in Prototype Ft Per Sec					
	Base Test 4			Test 10		
	41.6-Ft Rising Stage	53.6-Ft Crest Stage	41.6-Ft Falling Stage	41.6-Ft Rising Stage	53.6-Ft Crest Stage	41.6-Ft Falling Stage
Range 1						
250	---	---	---	---	---	---
550	---	---	---	---	---	---
1150	---	---	3.5	6.0	2.0	5.8
1750	3.0	1.4	6.0	6.7	4.9	5.5
2350	4.7	4.0	7.2	7.1	5.1	6.0
2950	6.7	3.0	7.2	6.7	7.6	7.7
3550	6.0	6.5	5.4	8.9	5.6	7.2
4150	---	7.6	6.4	7.6	8.7	6.7
4750	---	---	---	---	7.2	---
Range 2						
350	2.4	1.6	2.4	5.1	3.2	3.6
650	4.5	3.0	3.7	8.9	3.6	7.2
1250	6.0	4.0	6.0	10.7	5.8	9.7
1850	6.3	4.9	7.7	10.7	9.4	8.3
2450	7.6	6.3	7.2	9.6	10.1	8.3
3050	---	4.0	3.7	7.6	10.1	5.5
3650	---	---	---	---	7.2	---
Range 3						
370	8.2	4.5	8.9	12.1	13.8	8.9
670	7.6	6.9	8.9	12.1	15.8	8.9
1270	7.1	8.1	7.7	10.7	12.3	7.7
1870	6.7	6.9	6.7	8.9	10.1	5.8
2470	4.6	3.5	5.1	8.2	7.6	3.9
3070					4.8	
3670					2.3	

NOTE: All velocities were obtained with a miniature, propeller-type current meter run at a depth of 12 prototype feet below the water surface.

Photograph 1. View looking upstream from Memphis, showing type of roughness used in model adjustment.

Photograph 2. Base Test 1 (existing conditions) with fixed-bed showing current directions at crest of 1937 flood.

Photograph 3. Test 1 -- Plan 1 (entire improvement plan installed) with fixed-bed showing current directions at crest of 1937 flood.

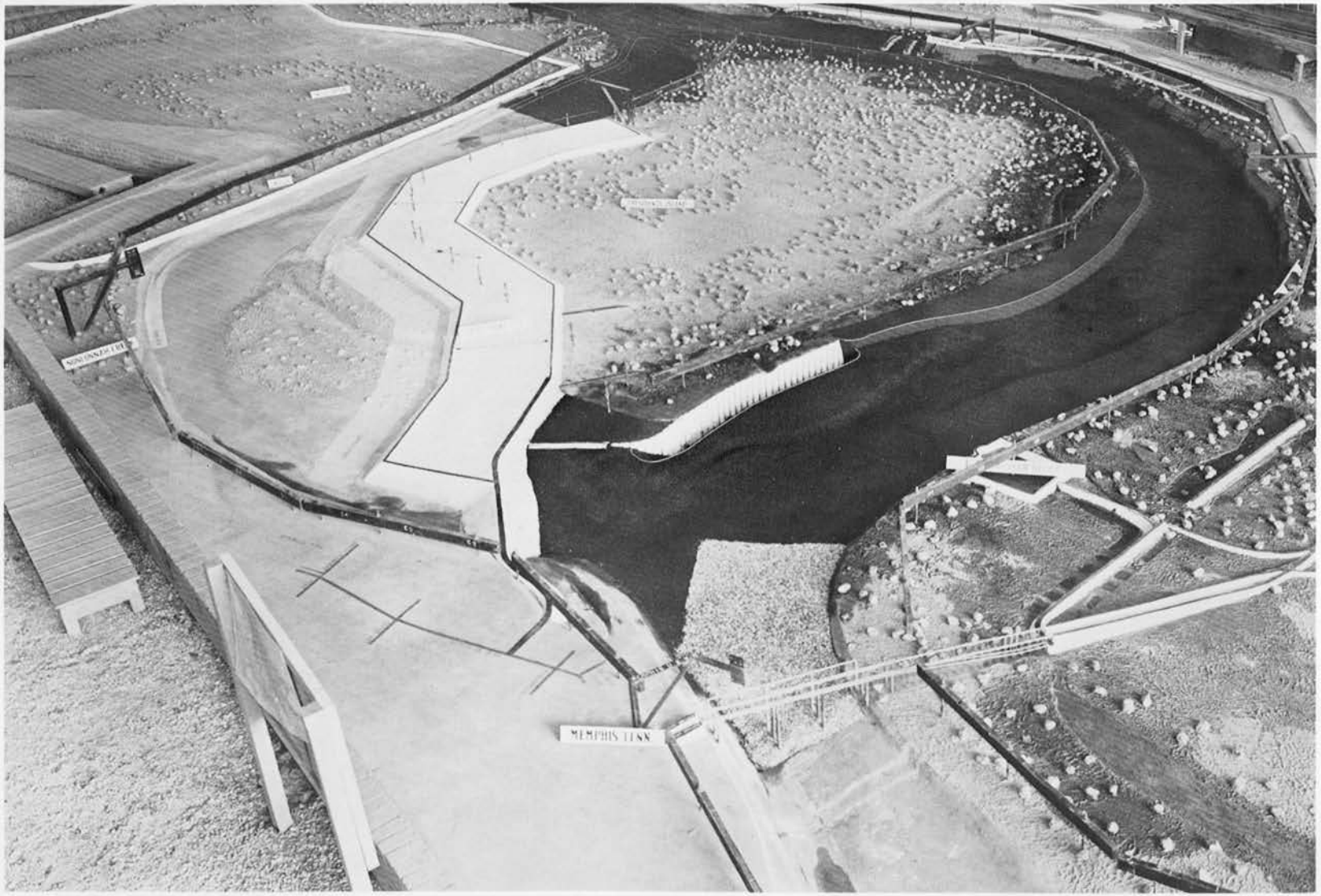
Photograph 4. Test 2 -- Plan 1 (left-bank chute levee removed) with fixed-bed showing current directions at crest of 1937 flood.

Photograph 5. Base Test 2 (existing conditions) with fixed-bed showing current directions at crest of project flood.

Photograph 6. Test 3 -- Plan 1 (entire improvement plan installed) with fixed-bed showing current directions at crest of project flood.

Photograph 7. Test 4 -- Plan 1 (left bank chute levee removed) with fixed-bed showing current directions at crest of project flood.

Photograph 8. Plan 2 as installed in model.



Photograph 9. Plan 6 as installed in model.

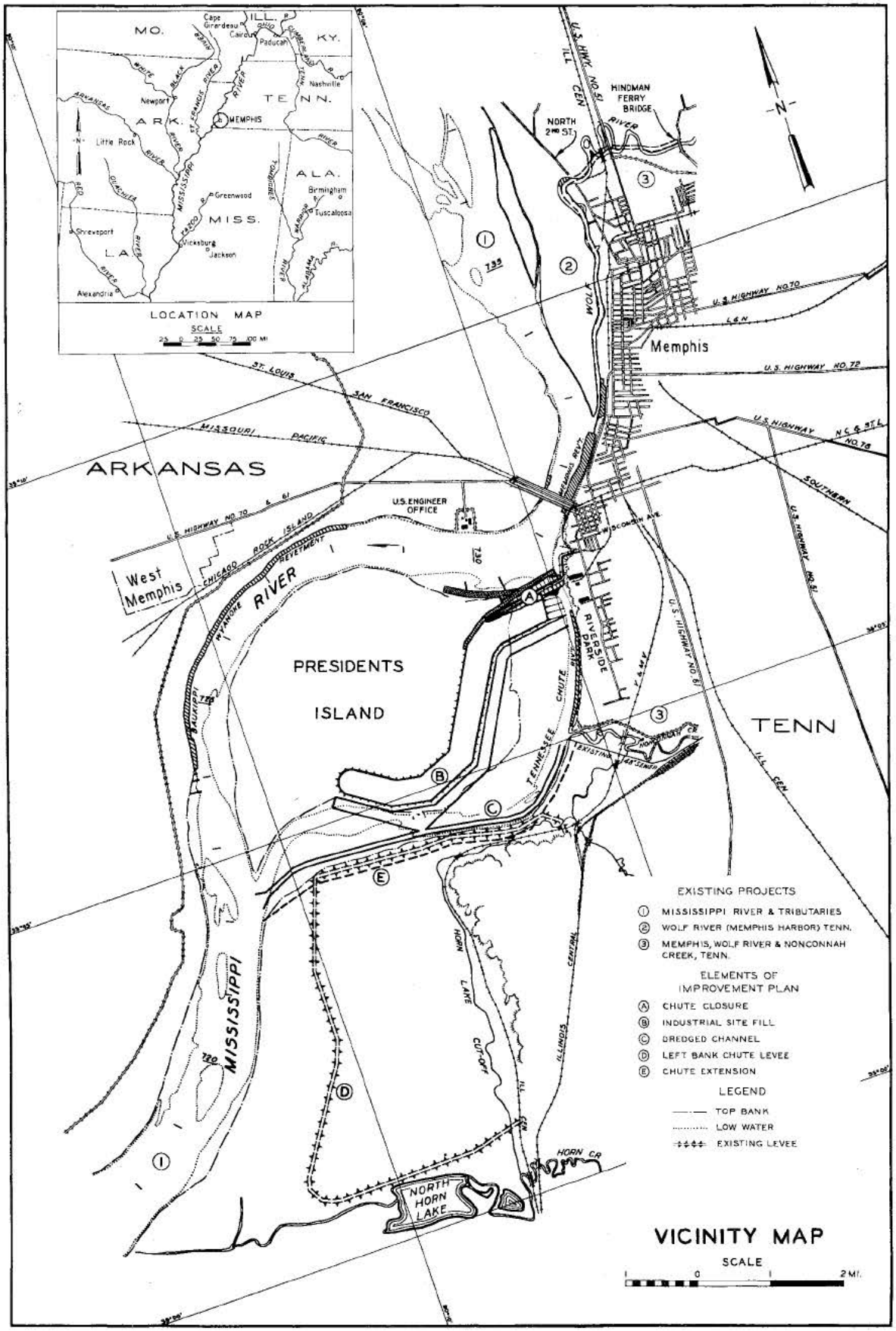

LOCATION MAP
SCALE
25 0 25 50 75 100 MI
MO.
ILL.
KY.
TENN.
ARK.
MISS.
ALA.
LA.
MEMPHIS
Cape Girardeau
Cairo
Paducah
Nashville
Newport
Little Rock
Greenwood
Vicksburg
Jackson
Shreveport
Alexandria
Birmingham
Tuscaloosa
ARKANSAS
Memphis
West Memphis
PRESIDENTS ISLAND
TENN
MISSISSIPPI RIVER
HINDMAN FERRY BRIDGE
NORTH 2ND ST.
U.S. ENGINEER OFFICE
RIVERSIDE PARK
WISCONSIN AVE.
HORN LAKE CUT-OFF
HORN CR.
NORTH HORN LAKE
ST. LOUIS SAN FRANCISCO
MISSOURI PACIFIC
CHICAGO ROCK ISLAND
ILL. CEN.
SOUTHERN
U.S. HIGHWAY NO. 70
U.S. HIGHWAY NO. 72
U.S. HIGHWAY NO. 61
U.S. HIGHWAY NO. 51
U.S. HIGHWAY NO. 79
N.C. & ST.L. NO. 76
EXISTING PROJECTS
① MISSISSIPPI RIVER & TRIBUTARIES
② WOLF RIVER (MEMPHIS HARBOR) TENN.
③ MEMPHIS, WOLF RIVER & NONCONNAH CREEK, TENN.
ELEMENTS OF IMPROVEMENT PLAN
Ⓐ CHUTE CLOSURE
Ⓑ INDUSTRIAL SITE FILL
Ⓒ DREDGED CHANNEL
Ⓓ LEFT BANK CHUTE LEVEE
Ⓔ CHUTE EXTENSION
LEGEND
TOP BANK
LOW WATER
EXISTING LEVEE
VICINITY MAP
SCALE
0 2 MI.

PLATE 1

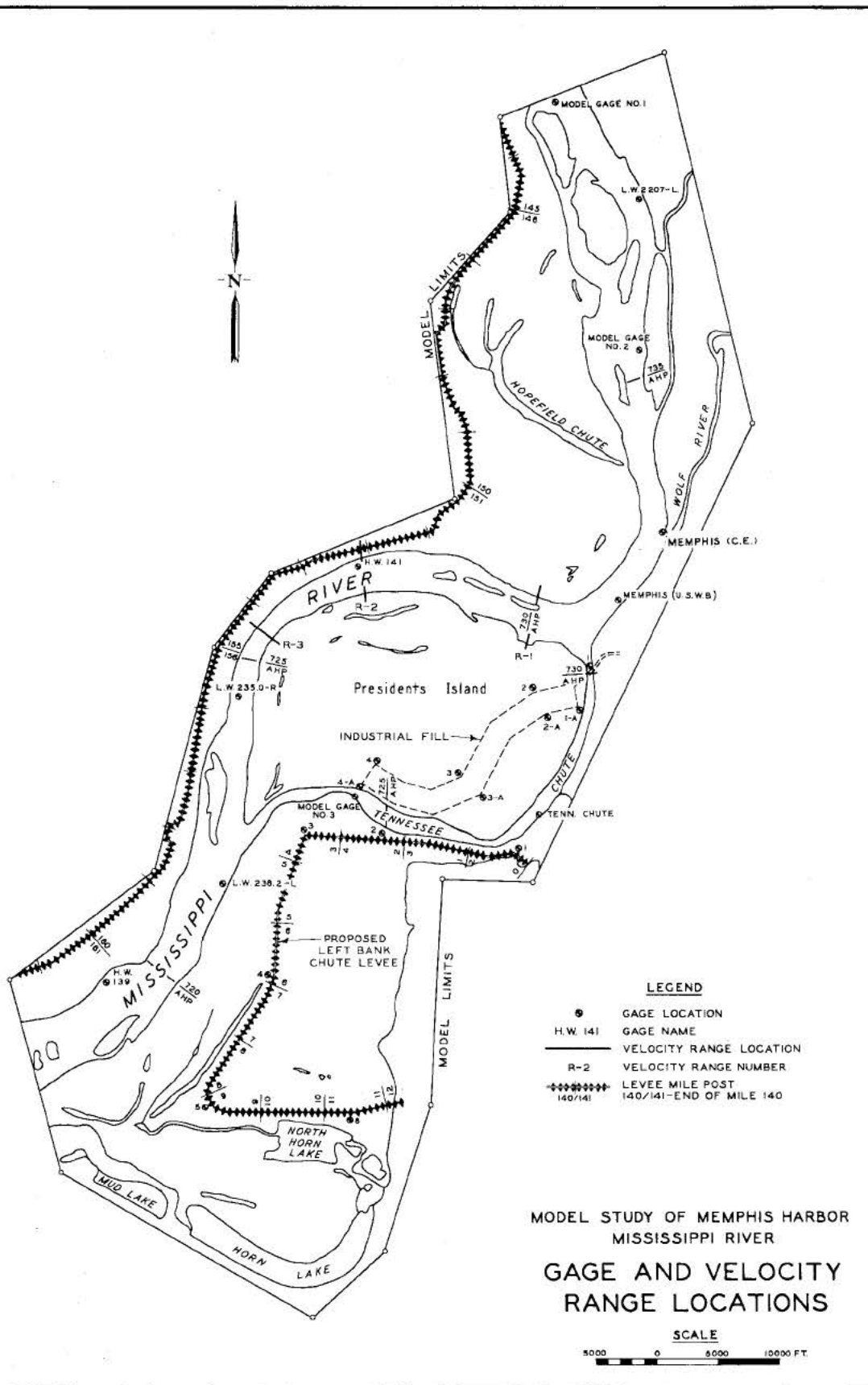
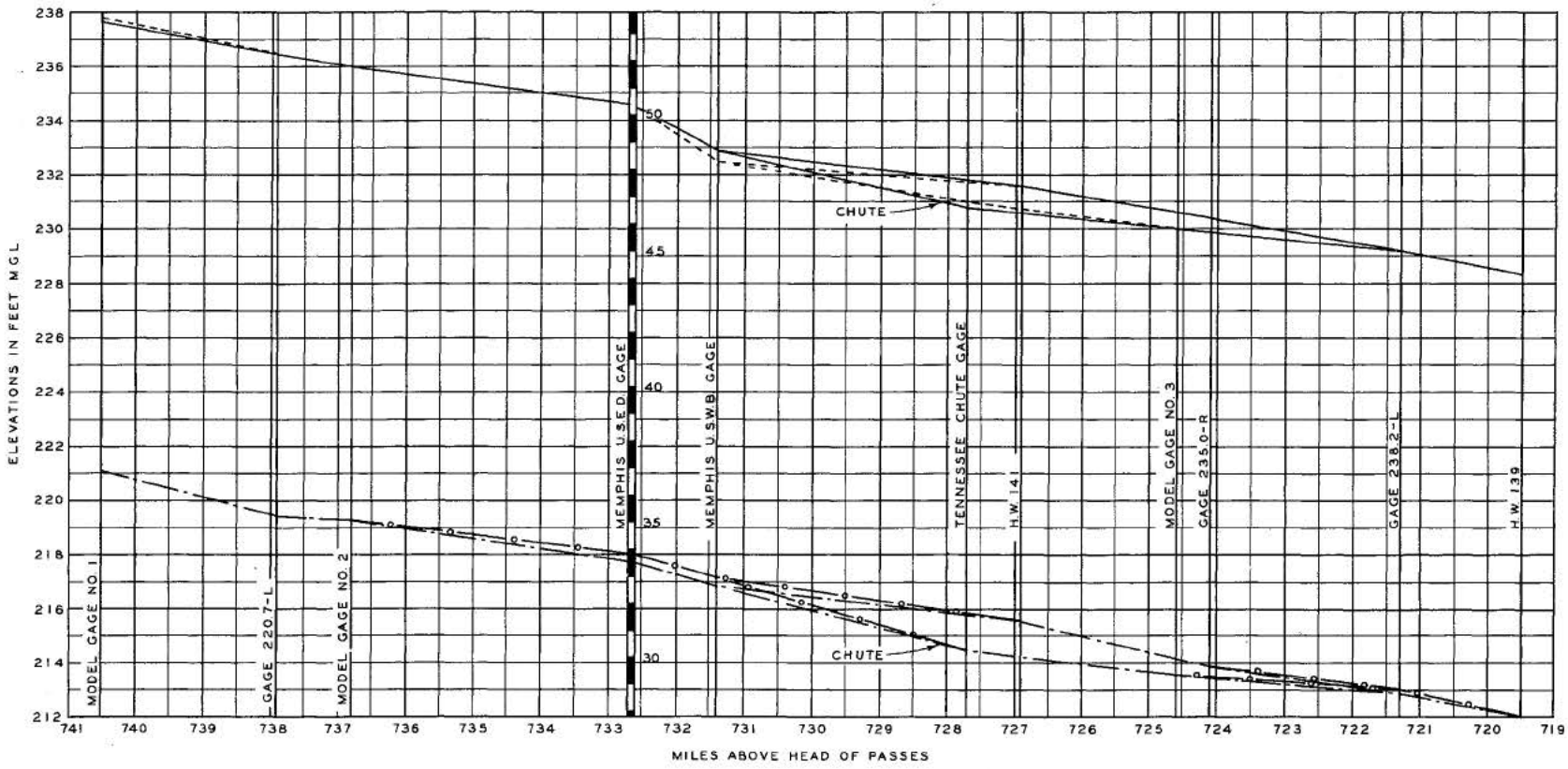

MODEL GAGE NO.1
L.W.2207-L
MODEL LIMITS
MODEL GAGE NO.2
735 AHP
HOPEFIELD CHUTE
WOLF RIVER
MEMPHIS (C.E.)
H.W. 141
MEMPHIS (U.S.W.B.)
RIVER
R-2
R-3
R-1
730 AHP
725 AHP
L.W.235.0-R
Presidents Island
INDUSTRIAL FILL
1-A
2-A
3-A
4-A
CHUTE
TENN. CHUTE
MODEL GAGE NO.3
TENNESSEE
L.W.238.2-L
MISSISSIPPI
PROPOSED LEFT BANK CHUTE LEVEE
H.W. 139
720 AHP
MODEL LIMITS
NORTH HORN LAKE
MUD LAKE
HORN LAKE
LEGEND
GAGE LOCATION
H.W. 141 GAGE NAME
VELOCITY RANGE LOCATION
R-2 VELOCITY RANGE NUMBER
140/141 LEVEE MILE POST 140/141-END OF MILE 140
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
GAGE AND VELOCITY RANGE LOCATIONS
SCALE
5000 0 5000 10000 FT.

PLATE 2



LEGEND

——— CREST FLOW—PROTOTYPE
- - - - - CREST FLOW—MODEL
—·— BANKFULL FLOW—PROTOTYPE
—○— BANKFULL FLOW—MODEL

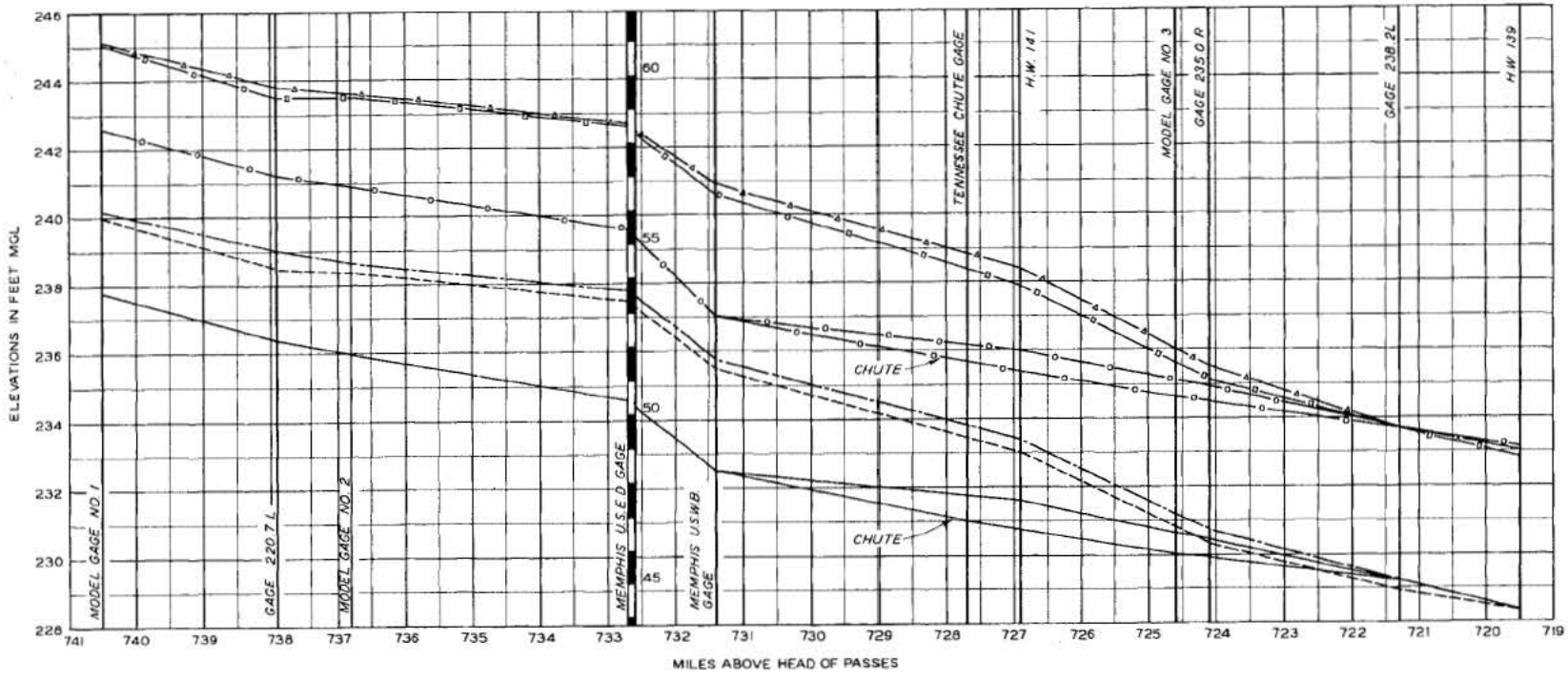
NOTES: DISCHARGES OF 2,020,000 CFS AND 1,066,000 CFS WERE USED FOR THE CREST FLOW AND THE BANKFULL FLOW, RESPECTIVELY. ZERO OF THE MEMPHIS U.S.E.D. GAGE IS 184.2 FT MGL.

WATER-SURFACE PROFILES

FIXED BED ADJUSTMENT

1937 FLOOD

PLATE 3



LEGEND

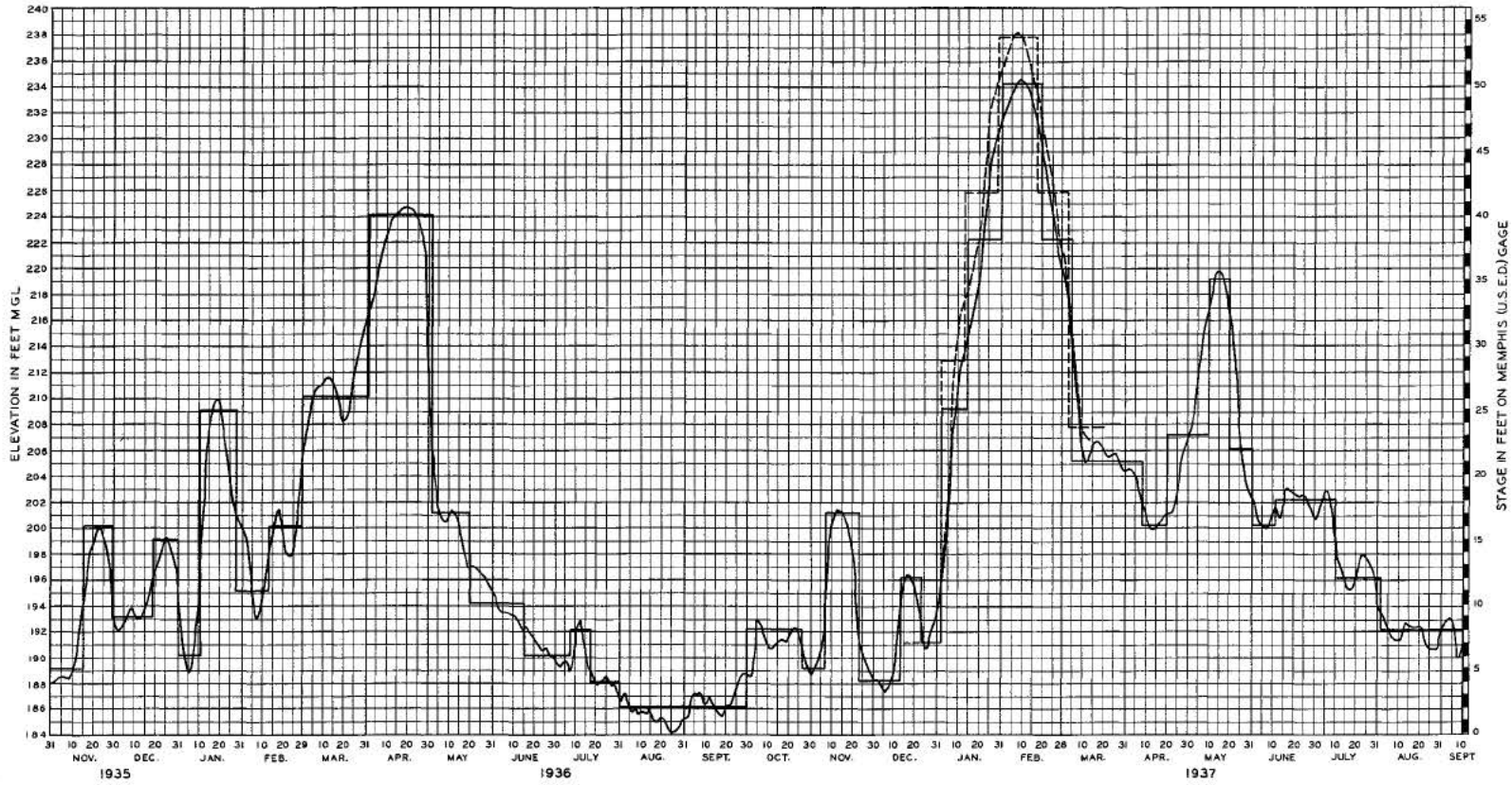
- 1937 FLOOD, BASE TEST 1
- PROJECT FLOOD, BASE TEST 2
- 1937 FLOOD, TEST 1 (ENTIRE PLAN INSTALLED)
- 1937 FLOOD, TEST 2 (PROPOSED LEVEE REMOVED)
- PROJECT FLOOD, TEST 3 (ENTIRE PLAN INSTALLED)
- PROJECT FLOOD, TEST 4 (PROPOSED LEVEE REMOVED)

NOTES: DISCHARGES OF 2,020,000 CFS AND 2,450,000 CFS WERE USED FOR THE 1937 FLOOD AND PROJECT FLOOD, RESPECTIVELY.
ZERO OF MEMPHIS ENGINEER GAGE IS 184.2 MGL.

CREST WATER-SURFACE PROFILES

FIXED-BED TESTS

PLATE 4



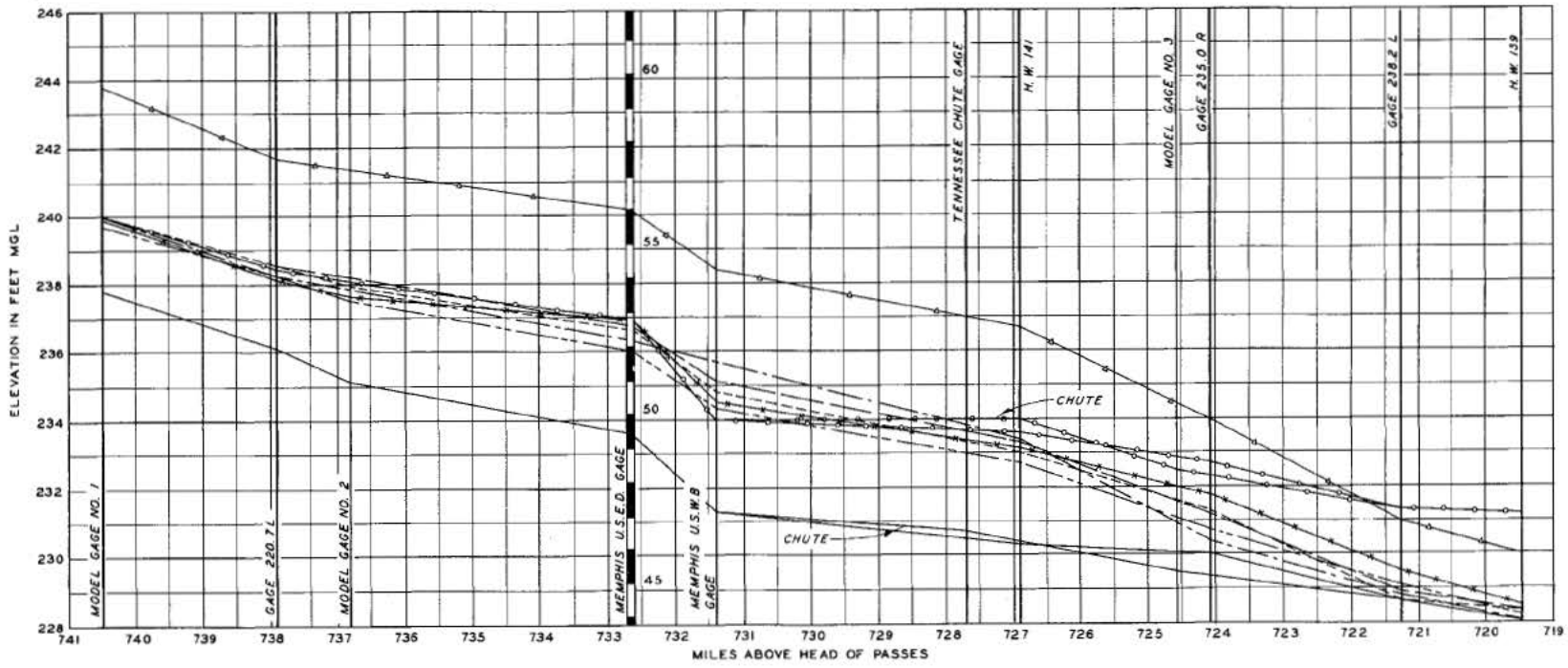
LEGEND

- 1935-37 PROTOTYPE HYDROGRAPH
- 1935-37 MODEL HYDROGRAPH
- PROJECT FLOOD COMPUTED HYDROGRAPH
- PROJECT FLOOD MODEL HYDROGRAPH

MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER

STAGE CONTROL HYDROGRAPH
MEMPHIS (C.E.) GAGE
MOVABLE-BED TESTS

PLATE 5



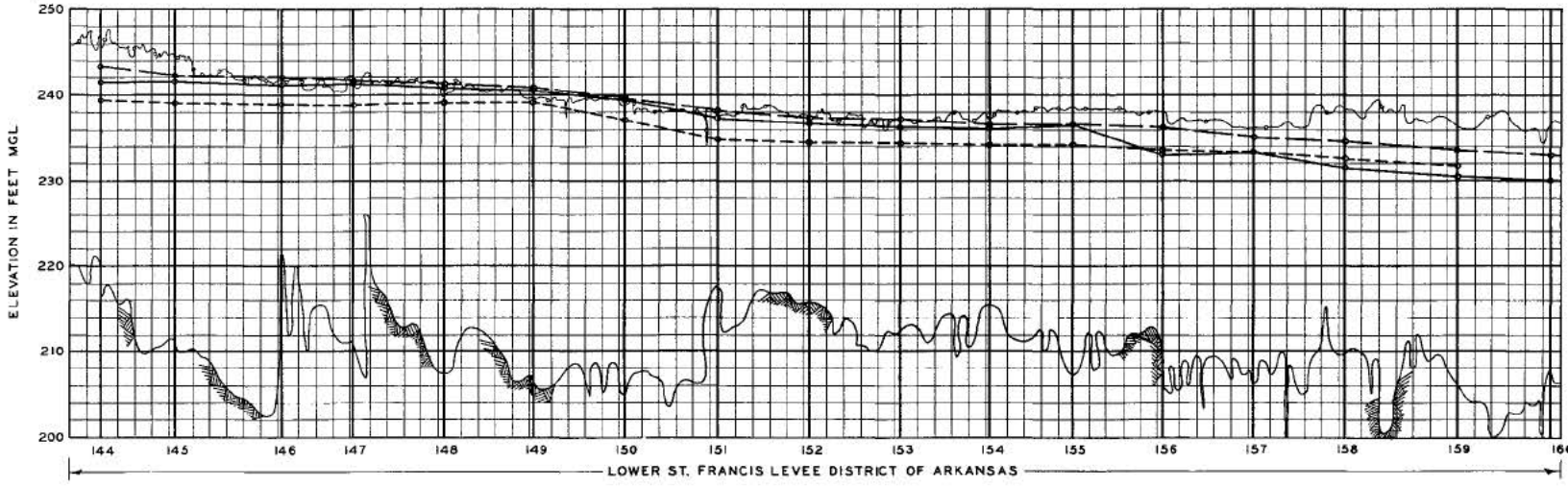
LEGEND

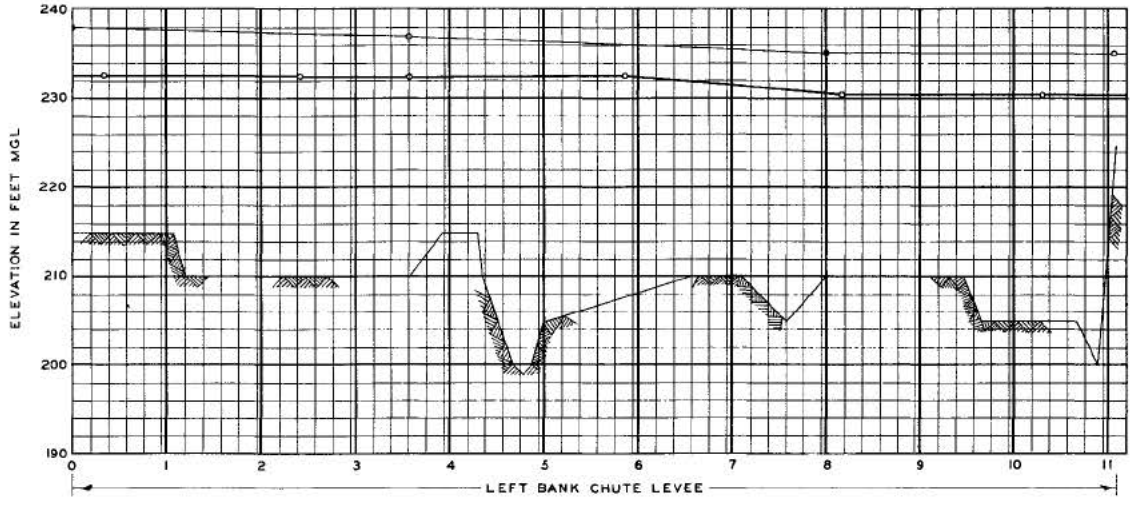
- 1937 FLOOD, BASE TEST 3
- PROJECT FLOOD, BASE TEST 4
- 1937 FLOOD TEST 5
- 1937 FLOOD TEST 6
- 1937 FLOOD TEST 7
- 1937 FLOOD TEST 8
- 1937 FLOOD TEST 9
- PROJECT FLOOD TEST 10

CREST WATER-SURFACE PROFILES

MOVABLE-BED TESTS

PLATE 6





LEGEND

- 1941 APPROVED GRADE-MAIN LEVEE
- PROPOSED GRADE-CHUTE LEVEE
- EXISTING GRADE-1942
- GROUND LINE
- 149 MILE POST 149-END OF MILE 149
- PROJECT FLOOD-TEST 10
- PROJECT FLOOD-BASE TEST 4

CREST WATER-SURFACE PROFILES

ALONG LEVEES

PLATE 7

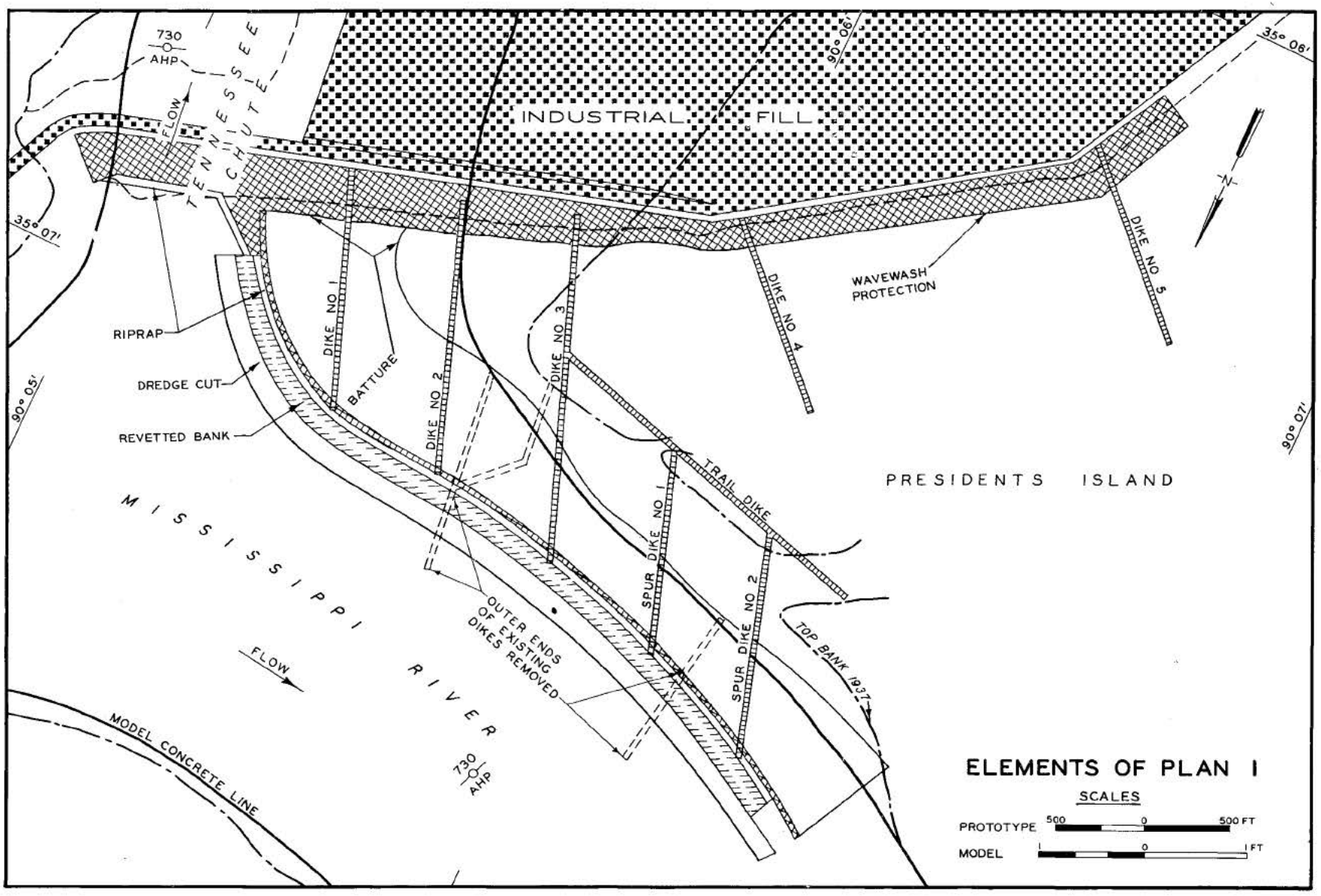

730
AHP
TENNESSEE
FLOW
INDUSTRIAL FILL
90° 06'
35° 06'
35° 07'
90° 05'
90° 07'
RIPRAP
DREDGE CUT
REVETTED BANK
DIKE NO 1
BATTURE
DIKE NO 2
DIKE NO 3
DIKE NO 4
DIKE NO 5
WAVEWASH PROTECTION
TRAIL DIKE
SPUR DIKE NO 1
SPUR DIKE NO 2
TOP BANK 1937
PRESIDENTS ISLAND
MISSISSIPPI RIVER
FLOW
OUTER ENDS OF EXISTING DIKES REMOVED
MODEL CONCRETE LINE
730
AHP
ELEMENTS OF PLAN I
SCALES
PROTOTYPE 500 0 500 FT
MODEL 0 1 FT

PLATE 8

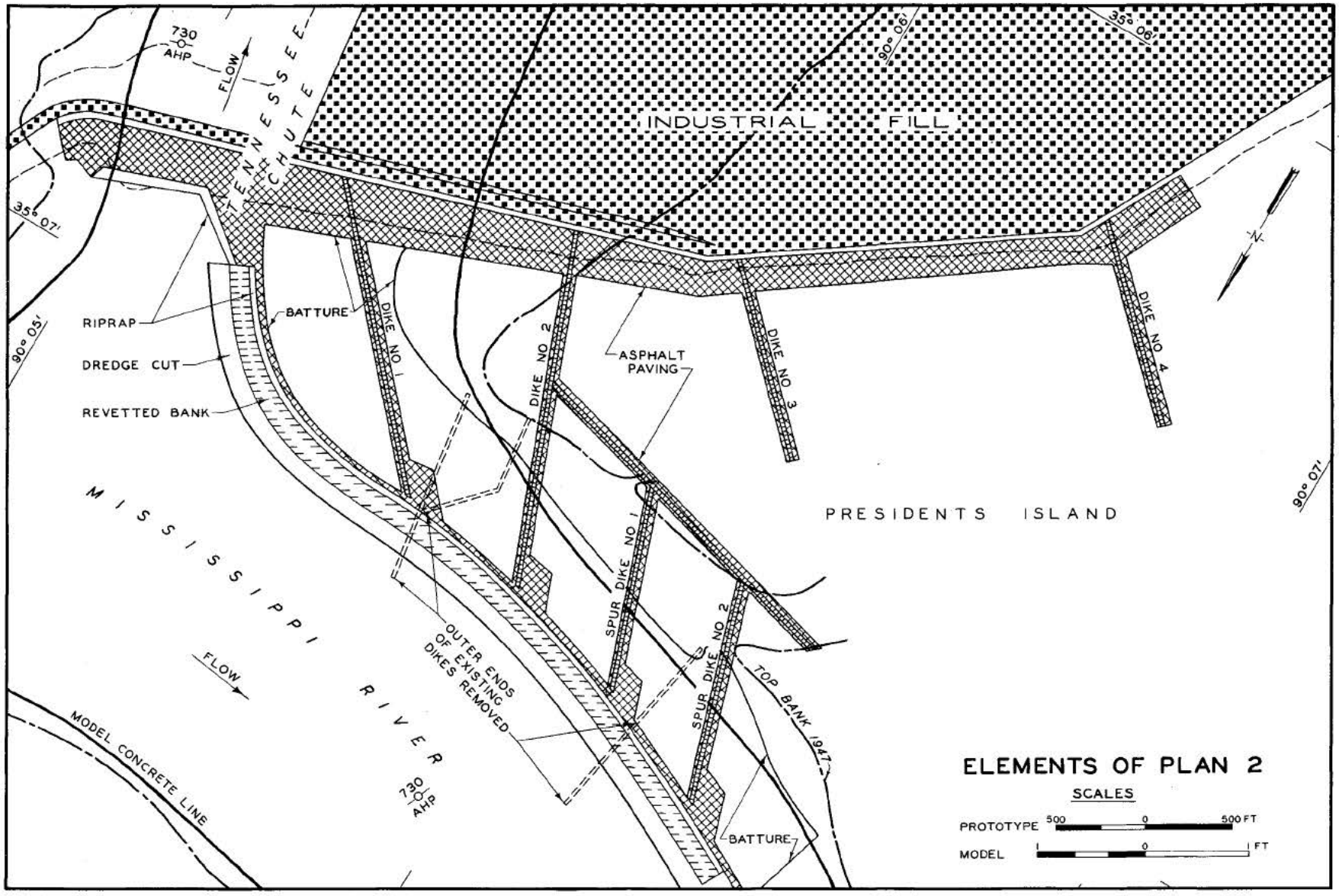

730
AHP
FLOW
TENNESSEE CHUTE
INDUSTRIAL FILL
35° 08'
90° 06'
35° 07'
90° 05'
90° 07'
RIPRAP
DREDGE CUT
REVETTED BANK
BATTURE
DIKE NO 1
DIKE NO 2
DIKE NO 3
DIKE NO 4
ASPHALT PAVING
PRESIDENTS ISLAND
MISSISSIPPI RIVER
FLOW
OUTER ENDS OF EXISTING DIKES REMOVED
SPUR DIKE NO 1
SPUR DIKE NO 2
TOP BANK 1947
BATTURE
MODEL CONCRETE LINE
730 AHP
N
ELEMENTS OF PLAN 2
SCALES
PROTOTYPE 500 0 500 FT
MODEL 1 0 FT

PLATE 9

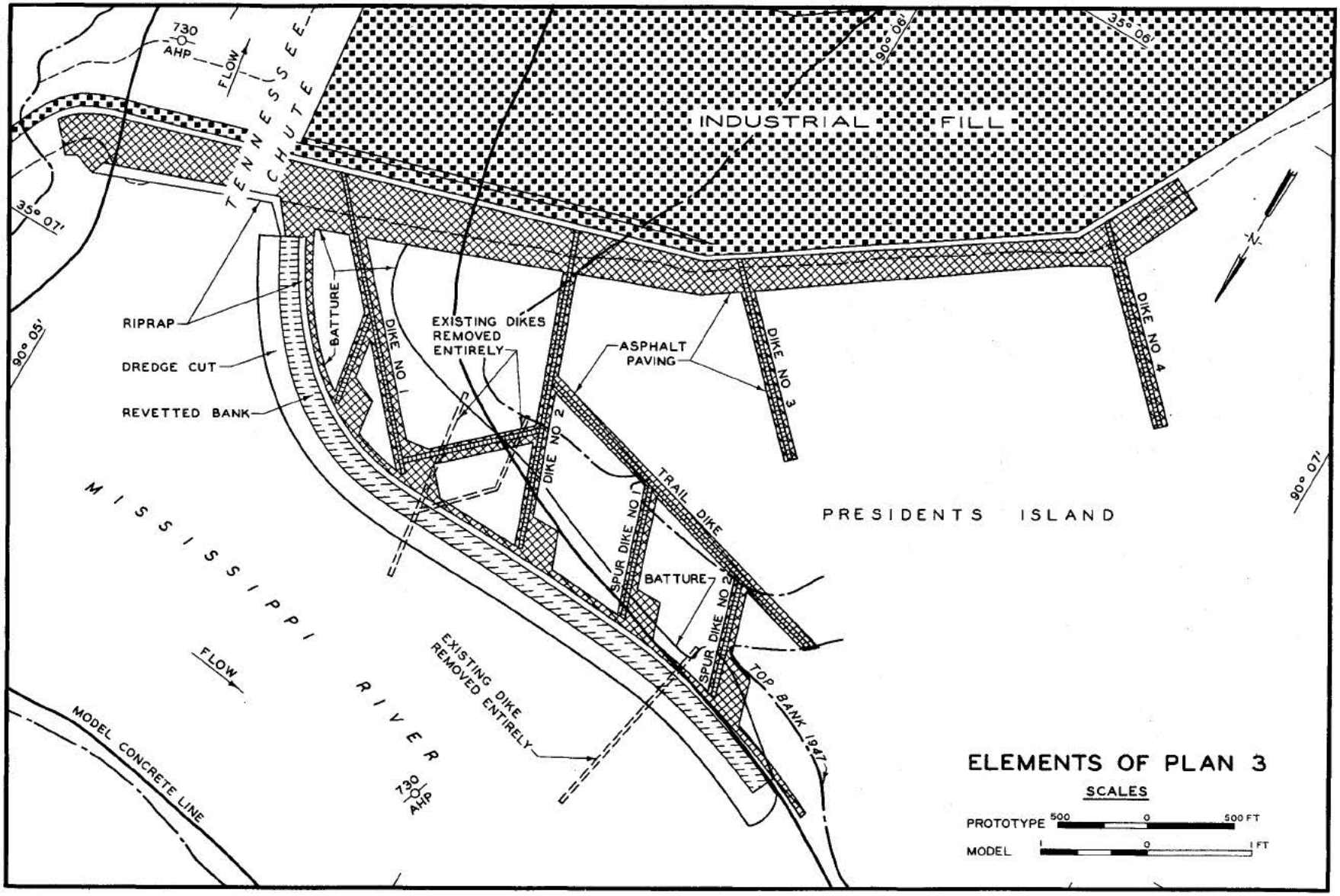

730
AHP
FLOW
TENNESSEE
CHUTE
INDUSTRIAL FILL
35° 07'
90° 06'
35° 05'
90° 05'
RIPRAP
DREDGE CUT
REVETTED BANK
BATTURE
DIKE NO 1
EXISTING DIKES
REMOVED
ENTIRELY
ASPHALT
PAVING
DIKE NO 3
DIKE NO 4
DIKE NO 2
TRAIL DIKE
SPUR DIKE NO 1
SPUR DIKE NO 2
BATTURE
PRESIDENTS ISLAND
90° 07'
MISSISSIPPI RIVER
FLOW
EXISTING DIKE
REMOVED ENTIRELY
TOP BANK 1947
MODEL CONCRETE LINE
730
AHP
ELEMENTS OF PLAN 3
SCALES
PROTOTYPE 500 0 500 FT
MODEL 1 0 1 FT

PLATE 10

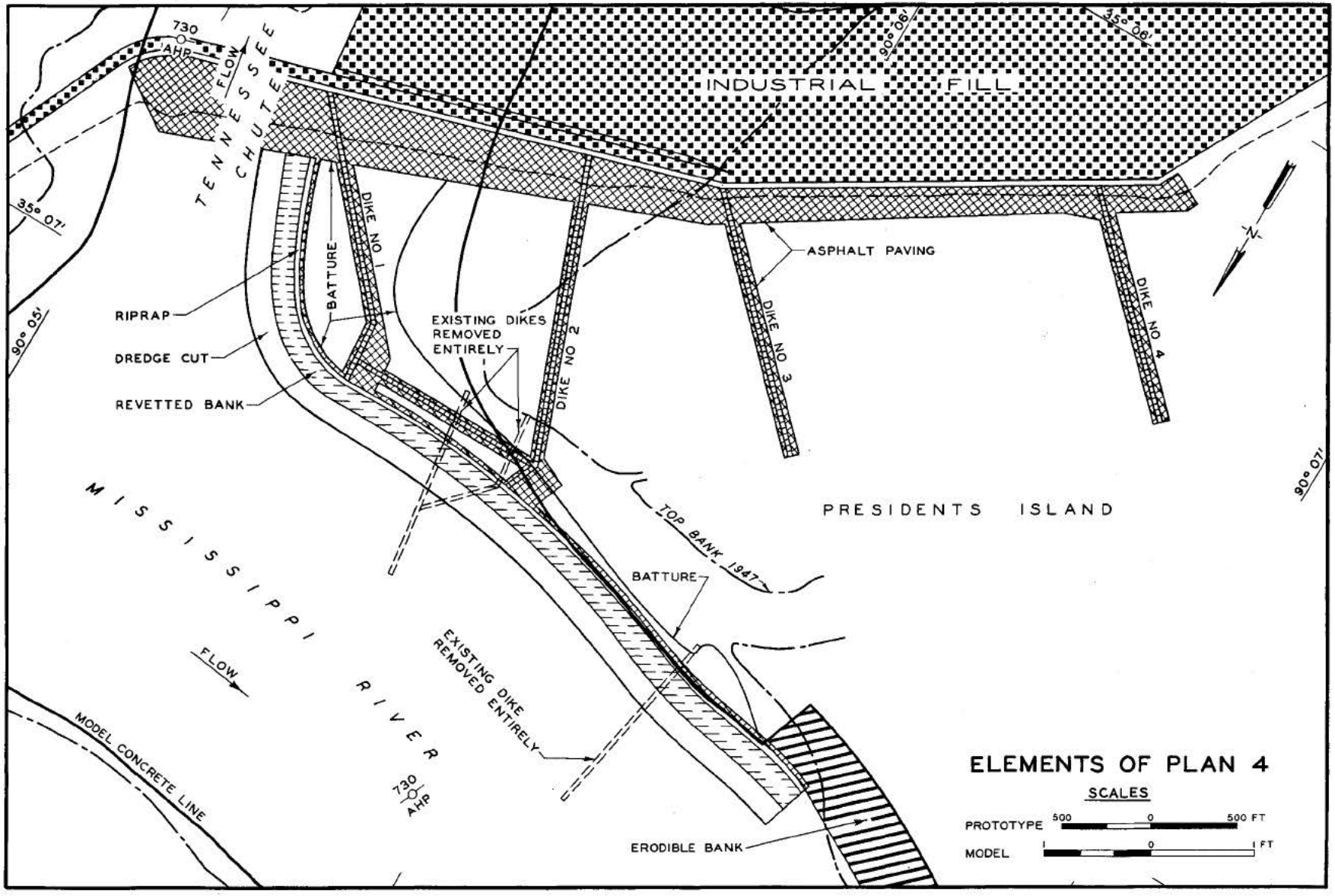

730
AHP
FLOW
TENNESSEE CHUTE
INDUSTRIAL FILL
90° 06'
35° 06'
35° 07'
90° 05'
90° 07'
DIKE NO 1
BATTURE
DIKE NO 2
DIKE NO 3
DIKE NO 4
ASPHALT PAVING
RIPRAP
DREDGE CUT
REVETTED BANK
EXISTING DIKES REMOVED ENTIRELY
PRESIDENTS ISLAND
TOP BANK 1947
BATTURE
MISSISSIPPI RIVER
FLOW
EXISTING DIKE REMOVED ENTIRELY
730
AHP
MODEL CONCRETE LINE
ERODIBLE BANK
ELEMENTS OF PLAN 4
SCALES
PROTOTYPE 500 0 500 FT
MODEL 1 0 1 FT

PLATE 11

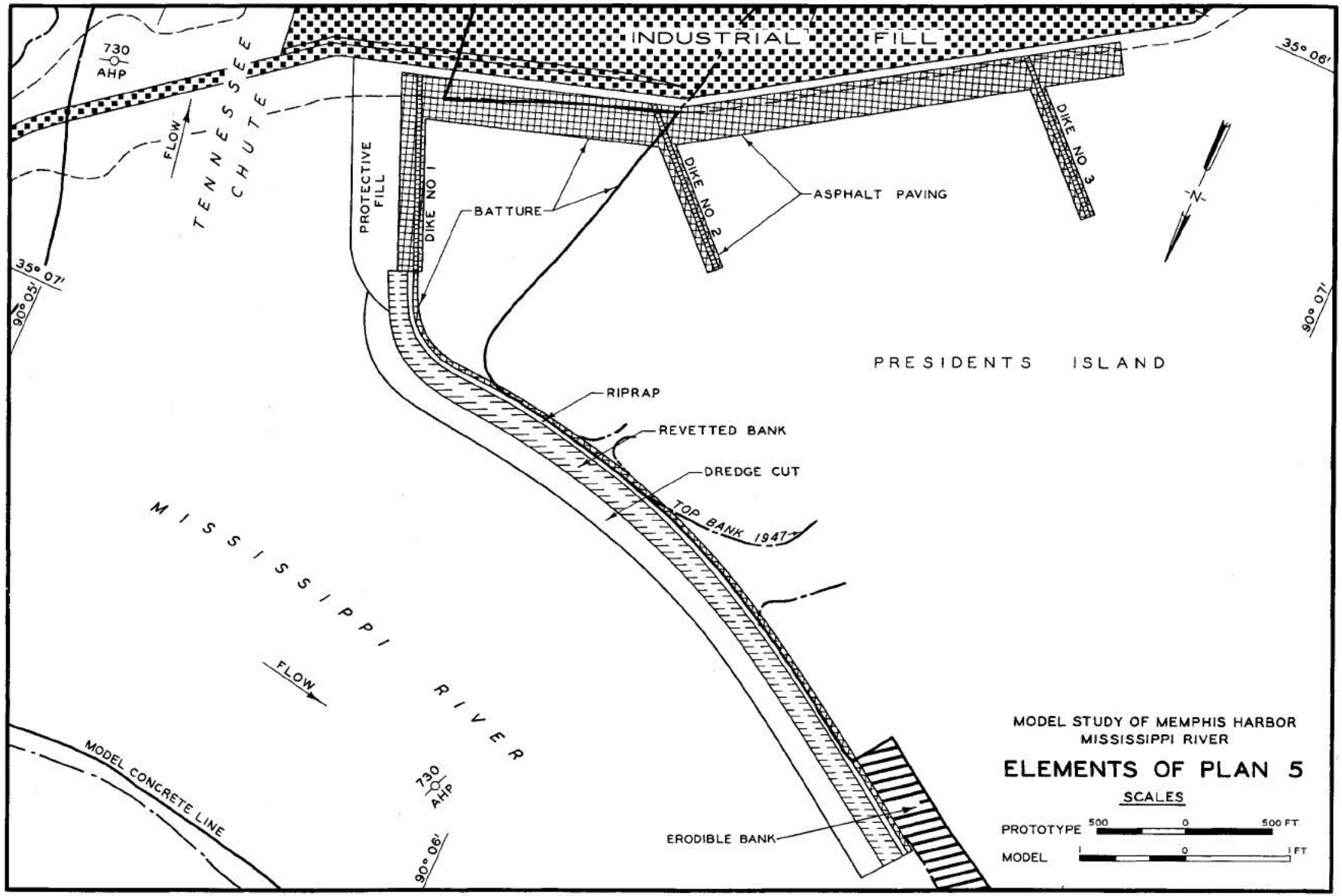

INDUSTRIAL FILL
730 AHP
TENNESSEE CHUTE
FLOW
PROTECTIVE FILL
DIKE NO 1
DIKE NO 2
DIKE NO 3
BATTURE
ASPHALT PAVING
35° 06'
35° 07'
90° 05'
90° 07'
PRESIDENTS ISLAND
RIPRAP
REVETTED BANK
DREDGE CUT
TOP BANK 1947
MISSISSIPPI RIVER
FLOW
MODEL CONCRETE LINE
730 AHP
90° 06'
ERODIBLE BANK
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
ELEMENTS OF PLAN 5
SCALES
PROTOTYPE 500 0 500 FT
MODEL 1 0 FT

PLATE 12

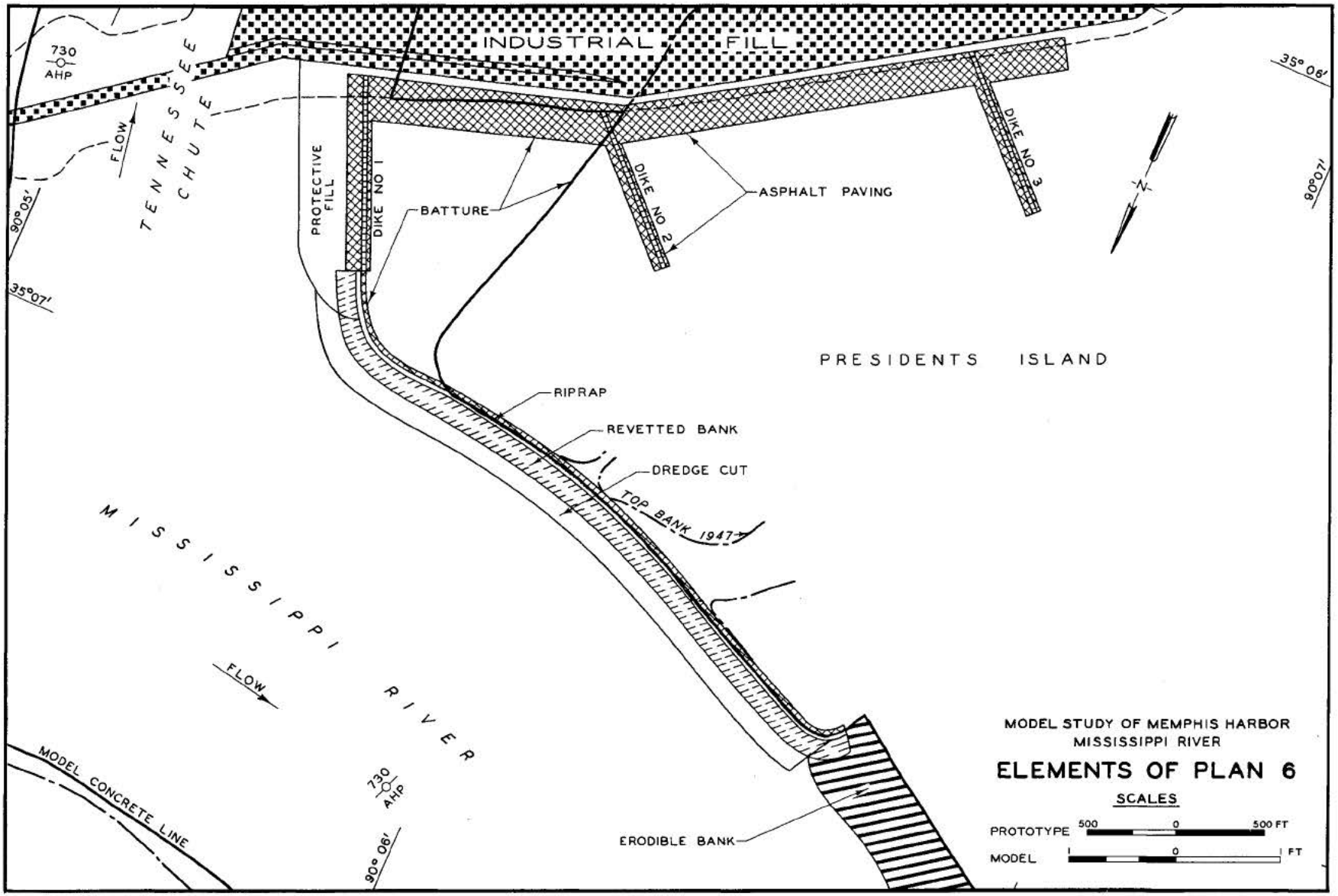

730
AHP
INDUSTRIAL FILL
35° 06'
TENNESSEE CHUTE
FLOW
PROTECTIVE FILL
DIKE NO 1
BATTURE
DIKE NO 2
ASPHALT PAVING
DIKE NO 3
90° 05'
90° 07'
35° 07'
PRESIDENTS ISLAND
RIPRAP
REVETTED BANK
DREDGE CUT
TOP BANK 1947
MISSISSIPPI RIVER
FLOW
MODEL CONCRETE LINE
730
AHP
90° 06'
ERODIBLE BANK
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
ELEMENTS OF PLAN 6
SCALES
PROTOTYPE 500 0 500 FT
MODEL 1 0 FT

PLATE 13

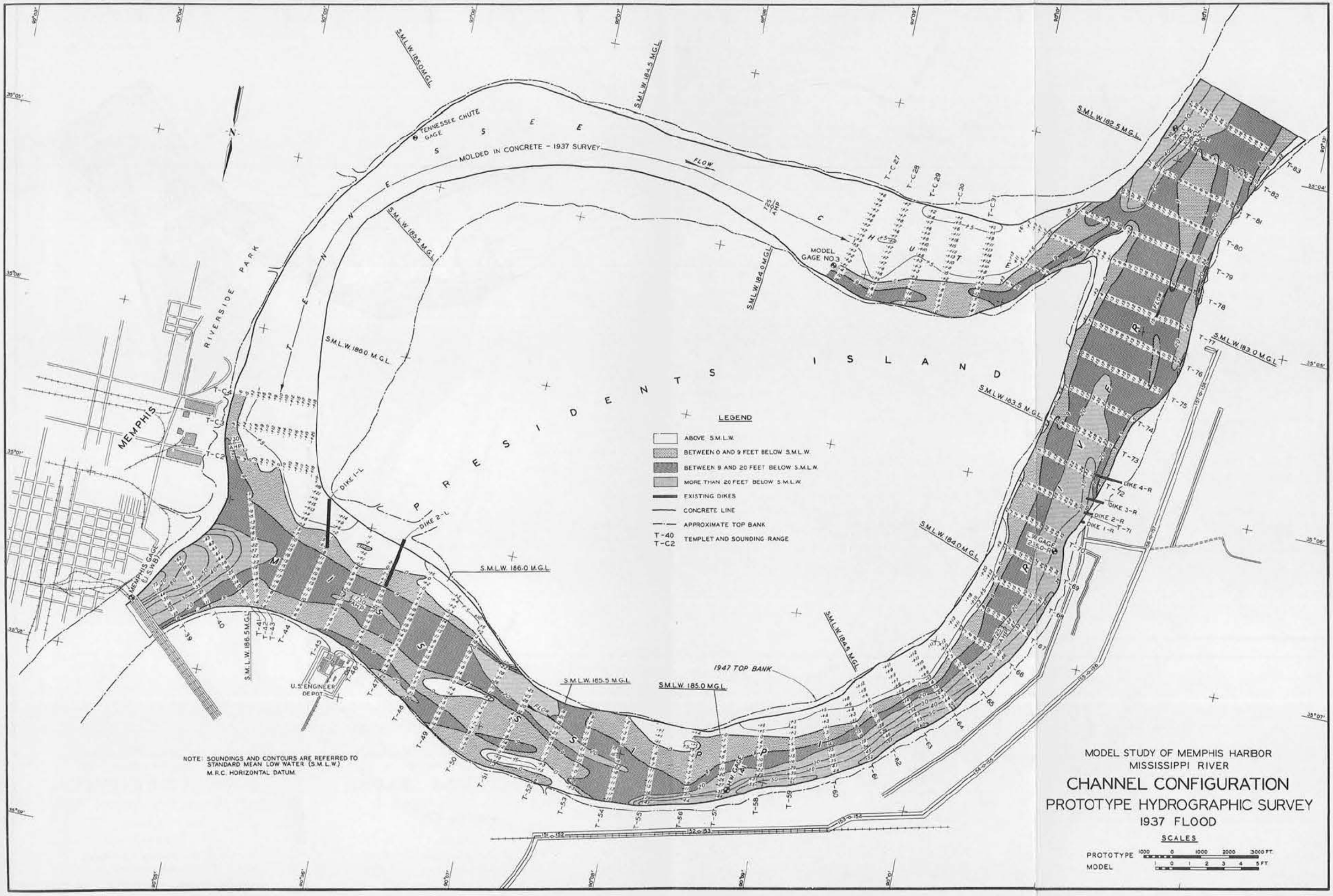

S.M.L.W. 185.0 M.G.L.
TENNESSEE CHUTE GAGE
MOLDED IN CONCRETE - 1937 SURVEY
FLOW
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 182.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 180.0 M.G.L.
S.M.L.W. 163.5 M.G.L.
MODEL GAGE NO. 3
RIVERSIDE PARK
MEMPHIS
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
DIKE 1-L
DIKE 2-L
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
1947 TOP BANK
S.M.L.W. GAGE 22.6-R
T-C27
T-C28
T-C29
T-C30
T-C31
T-83
T-82
T-81
T-80
T-79
T-78
T-77
T-76
T-75
T-74
T-73
T-72
T-71
T-70
T-69
T-68
T-67
T-66
T-65
T-64
T-63
T-62
T-61
T-60
T-59
T-58
T-57
T-56
T-55
T-54
T-53
T-52
T-51
T-50
T-49
T-48
T-47
T-46
T-45
T-44
T-43
T-42
T-41
T-40
T-39
T-C4
T-C3
T-C2
135-0-136
152-0-153
154-0-155
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
EXISTING DIKES
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.)
M.R.C. HORIZONTAL DATUM
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PROTOTYPE HYDROGRAPHIC SURVEY
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT

PLATE 14

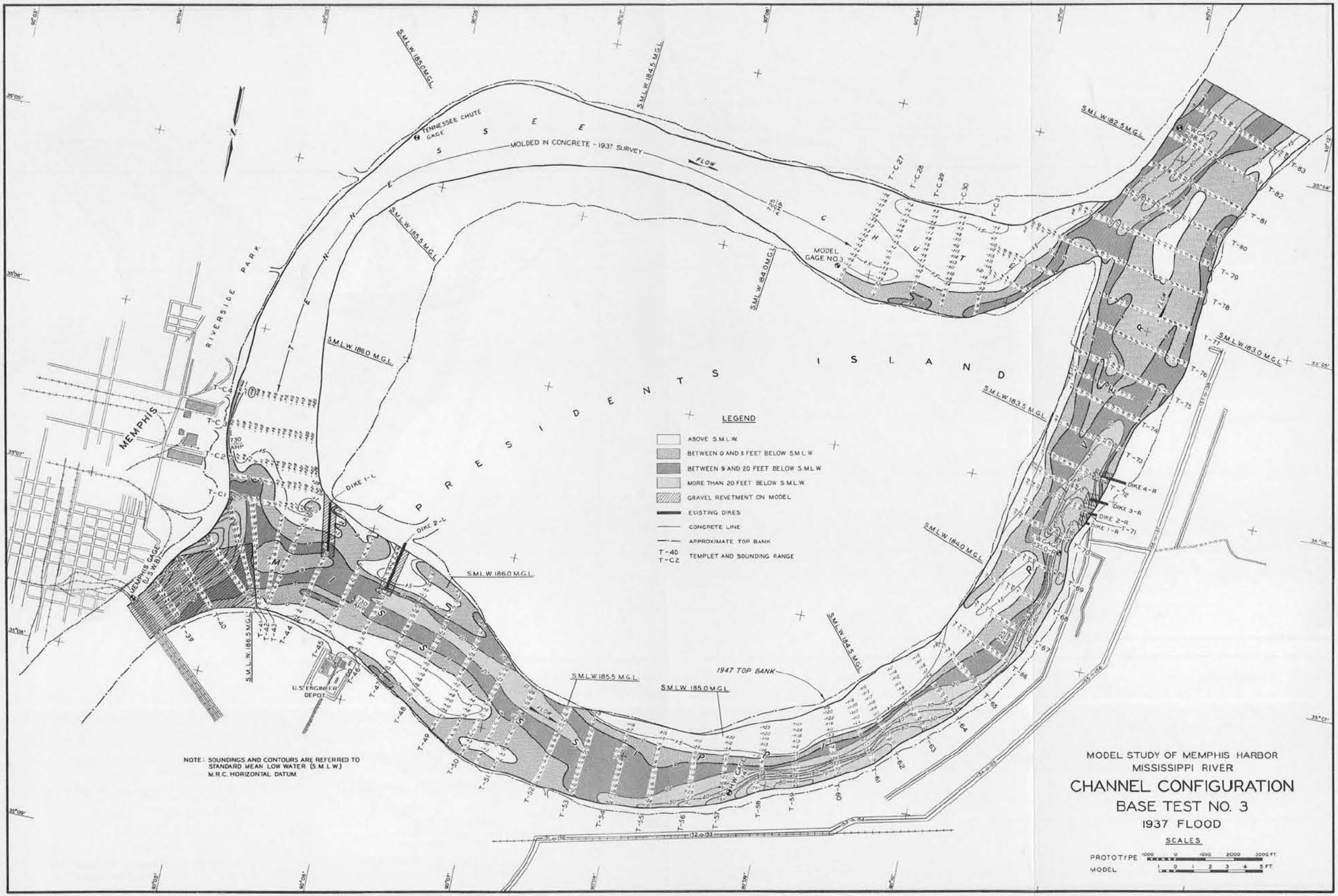

TENNESSEE CHUTE
GAGE
MOLDED IN CONCRETE - 1937 SURVEY
FLOW
MODEL
GAGE NO. 3
RIVERSIDE PARK
MEMPHIS
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
DIKE 1-L
DIKE 2-L
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
1947 TOP BANK
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 182.5 M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
T-C1
T-C2
T-C3
T-C4
T-C27
T-C28
T-C29
T-C30
T-C31
T-39
T-40
T-41
T-42
T-43
T-44
T-45
T-46
T-47
T-48
T-49
T-50
T-51
T-52
T-53
T-54
T-55
T-56
T-57
T-58
T-59
T-60
T-61
T-62
T-63
T-64
T-65
T-66
T-67
T-68
T-69
T-70
T-71
T-72
T-73
T-74
T-75
T-76
T-77
T-78
T-79
T-80
T-81
T-82
T-83
730 AMP
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
GRAVEL REVETMENT ON MODEL
EXISTING DIKES
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
BASE TEST NO. 3
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 15

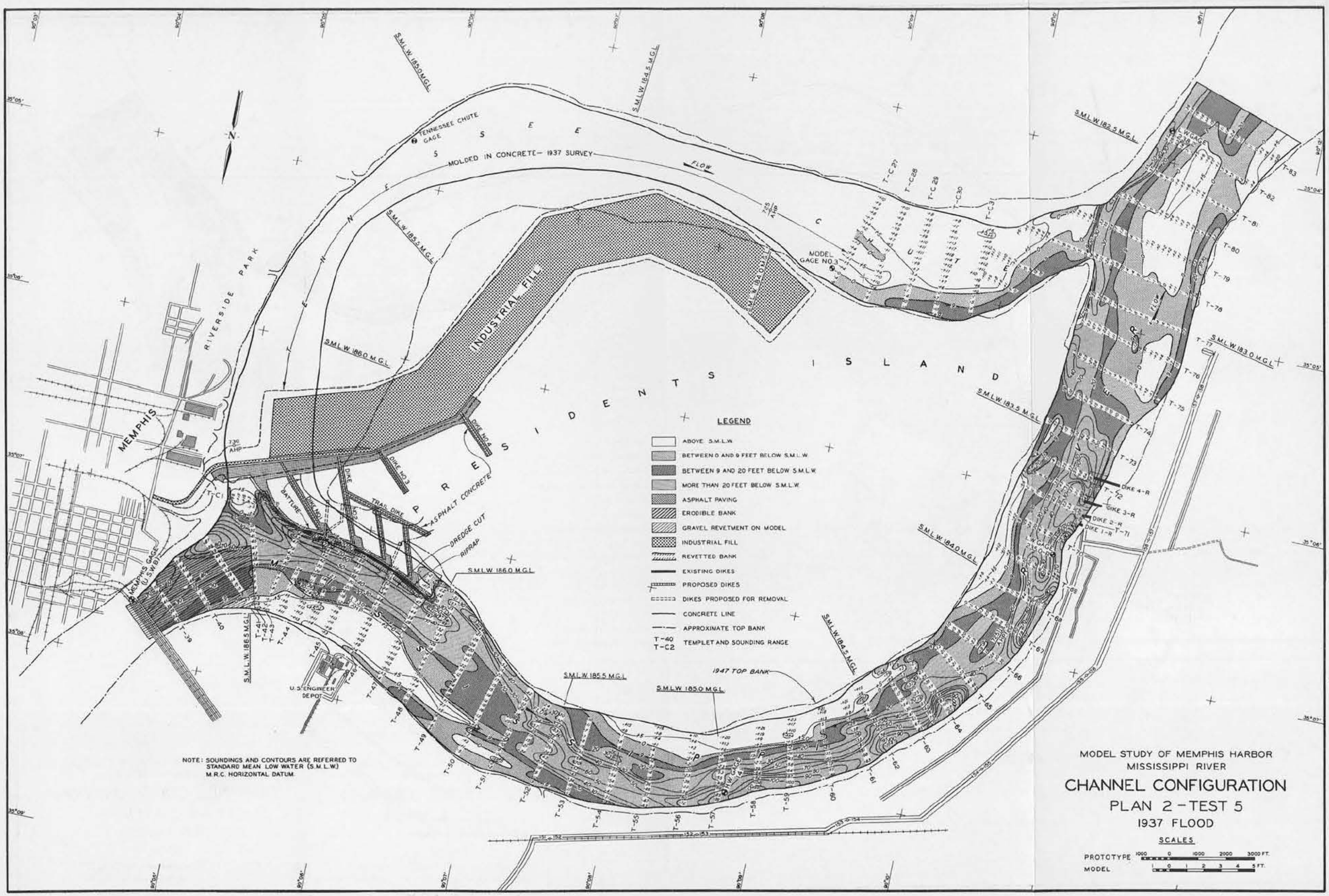

TENNESSEE CHUTE
GAGE
MOLDED IN CONCRETE— 1937 SURVEY
FLOW
S E E S
N E C H U T E
RIVERSIDE PARK
MEMPHIS
INDUSTRIAL FILL
MODEL GAGE NO.3
S.M.L.W.185.0 M.G.L.
S.M.L.W.186.0 M.G.L.
S.M.L.W.184.5 M.G.L.
S.M.L.W.182.5 M.G.L.
S.M.L.W.183.0 M.G.L.
S.M.L.W.183.5 M.G.L.
S.M.L.W.184.0 M.G.L.
S.M.L.W.185.5 M.G.L.
S.M.L.W.186.5 M.G.L.
RESIDENTS ISLAND
DIKE NO.4
DIKE NO.3
TRAIL DIKE
ASPHALT CONCRETE
DREDGE CUT
RIPRAP
1947 TOP BANK
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ASPHALT PAVING
ERODIBLE BANK
GRAVEL REVETMENT ON MODEL
INDUSTRIAL FILL
REVETTED BANK
EXISTING DIKES
PROPOSED DIKES
DIKES PROPOSED FOR REMOVAL
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM.
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN 2 – TEST 5
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 16

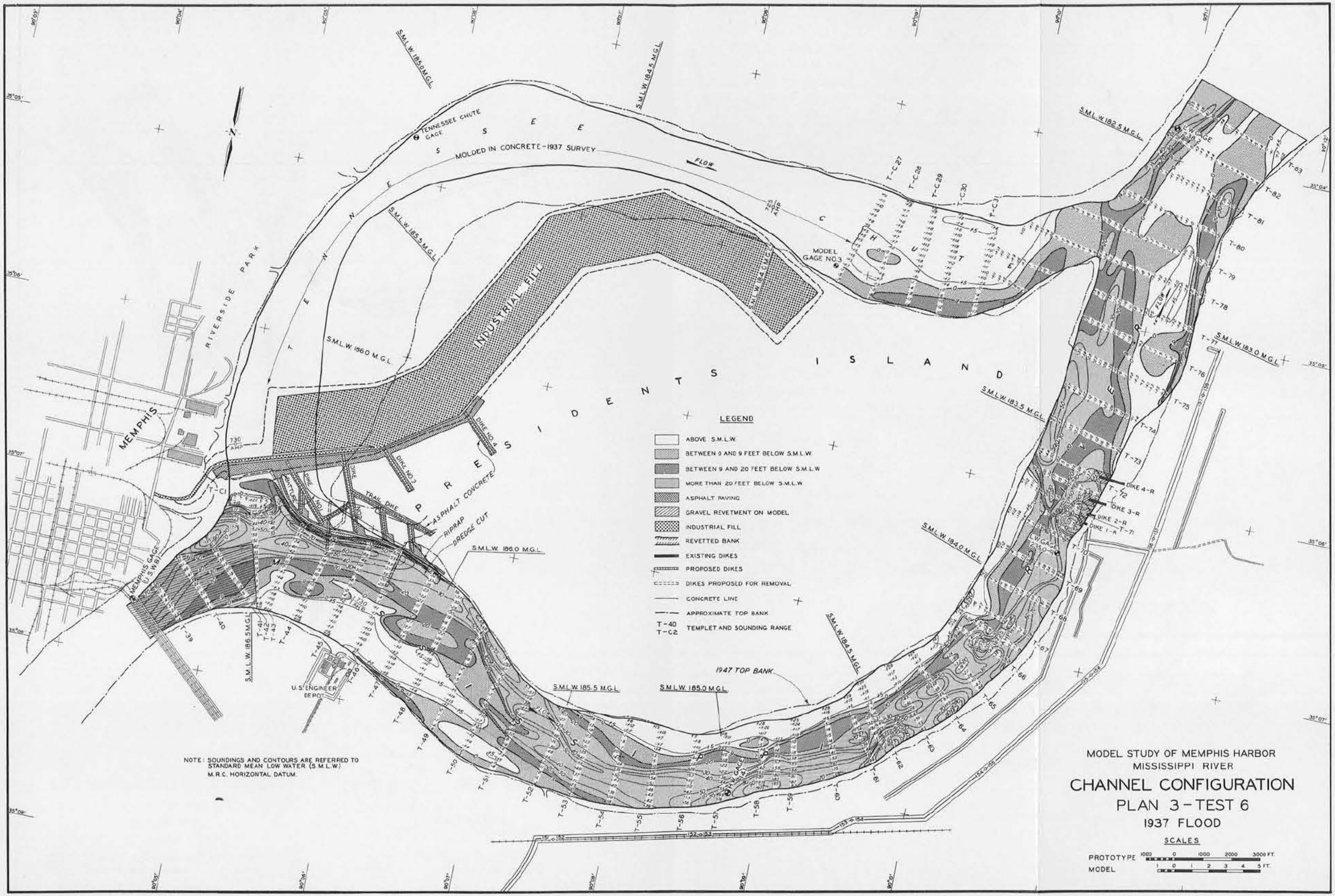
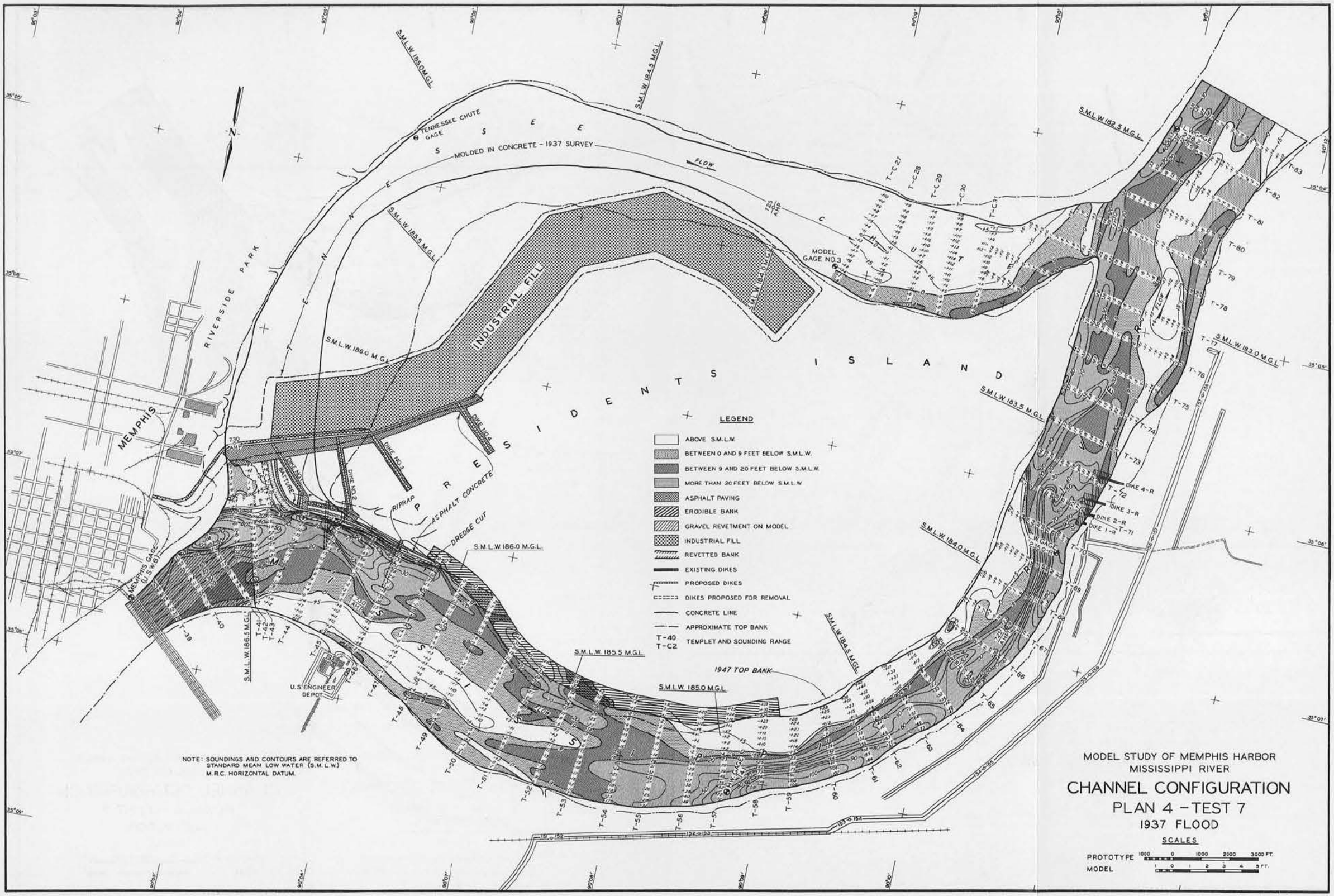

MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN 3 - TEST 6
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ASPHALT PAVING
GRAVEL REVETMENT ON MODEL
INDUSTRIAL FILL
REVETTED BANK
EXISTING DIKES
PROPOSED DIKES
DIKES PROPOSED FOR REMOVAL
CONCRETE LINE
APPROXIMATE TOP BANK
T-40
T-C2
TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM.
MEMPHIS
RIVERSIDE PARK
TENNESSEE CHUTE
PRESIDENTS ISLAND
MISSISSIPPI RIVER
INDUSTRIAL FILL
TENNESSEE CHUTE GAGE
MOLDED IN CONCRETE-1937 SURVEY
FLOW
MODEL GAGE NO.3
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
1947 TOP BANK
ASPHALT CONCRETE
RIPRAP
DREDGE CUT
TRAIL DIKE
DIKE NO.3
DIKE NO.4
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-A
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 182.5 M.G.L.

PLATE 17



MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER

CHANNEL CONFIGURATION
PLAN 4 - TEST 7
1937 FLOOD

SCALES

PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 18

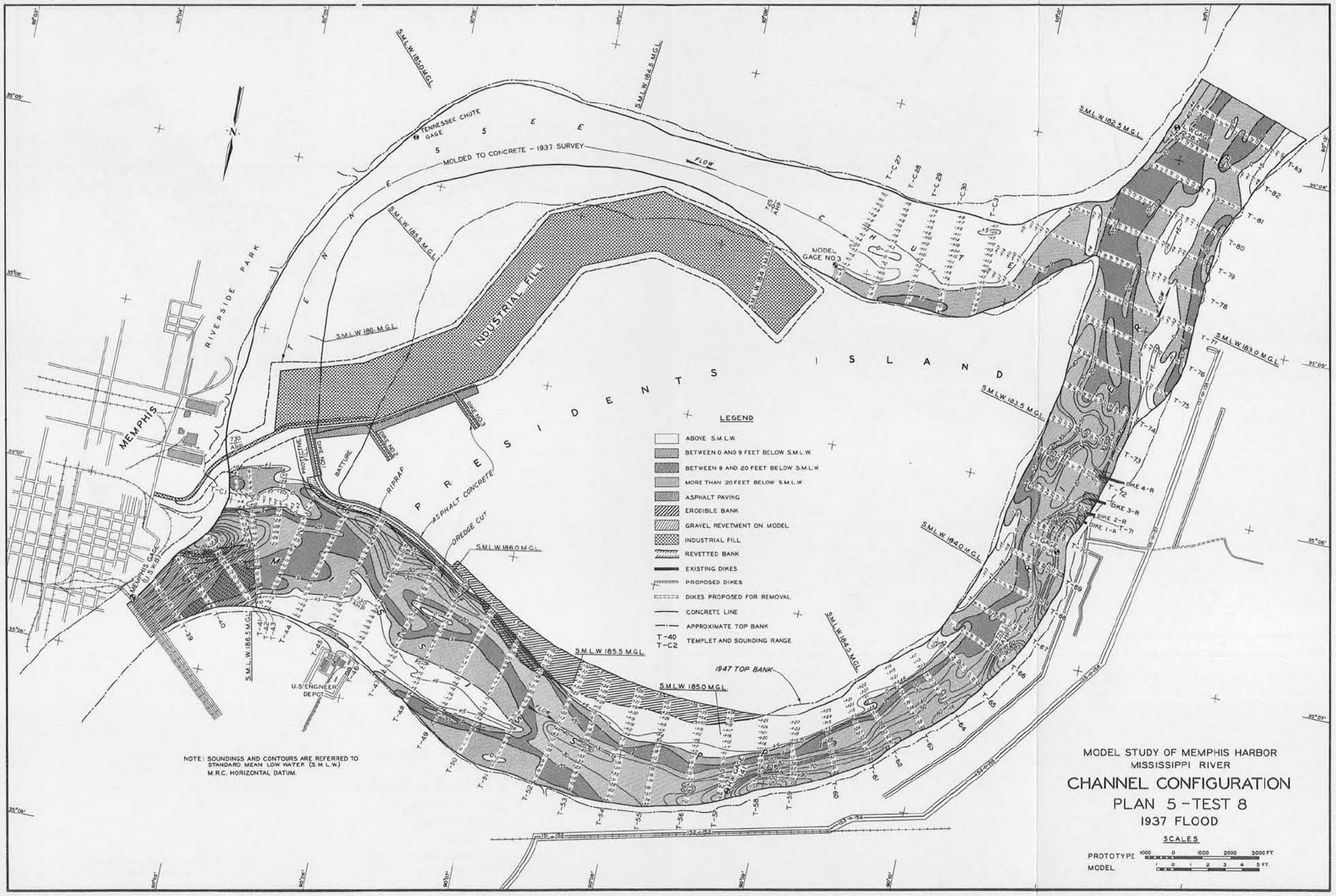

TENNESSEE CHUTE
GAGE
MOLDED TO CONCRETE – 1937 SURVEY
FLOW
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 182.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 186. M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 185.0 M.G.L.
1947 TOP BANK
INDUSTRIAL FILL
RIVERSIDE PARK
MEMPHIS
PRESIDENTS ISLAND
MODEL GAGE NO 3
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
W GAGE
L GAGE
DIKE NO. 1
DIKE NO. 2
DIKE NO. 3
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
PROTECTIVE REVETMENT
BATTURE
RIPRAP
ASPHALT CONCRETE
DREDGE CUT
730 AHP
7-45 AHP
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ASPHALT PAVING
ERODIBLE BANK
GRAVEL REVETMENT ON MODEL
INDUSTRIAL FILL
REVETTED BANK
EXISTING DIKES
PROPOSED DIKES
DIKES PROPOSED FOR REMOVAL
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM.
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN 5 – TEST 8
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 19

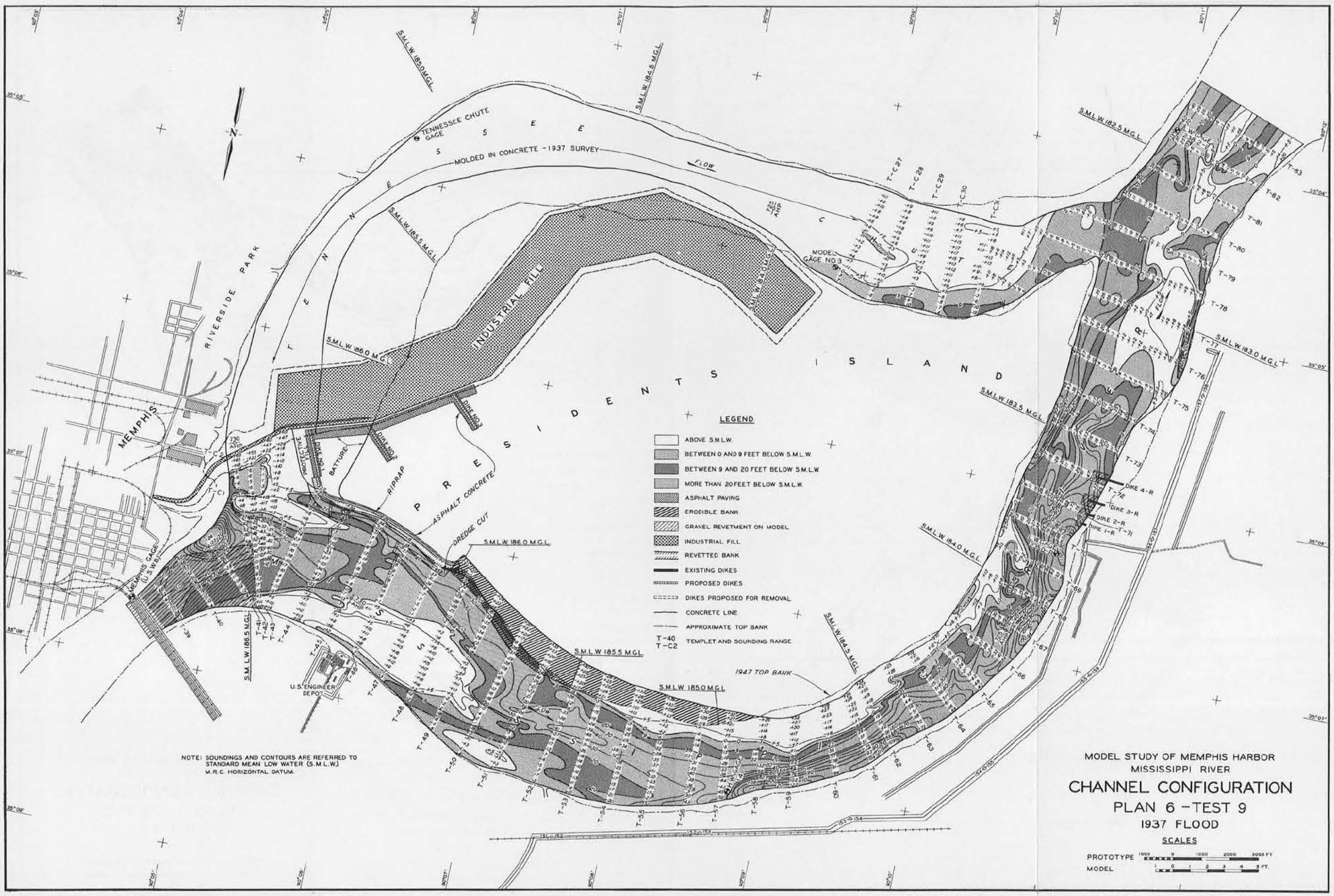

S.M.L.W. 180 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 182.5 M.G.L.
TENNESSEE CHUTE
GAGE
MOLDED IN CONCRETE - 1937 SURVEY
FLOW
S.M.L.W. 185.5 M.G.L.
INDUSTRIAL FILL
S.M.L.W. 184.0 M.G.L.
MODEL GAGE NO. 3
S.M.L.W. 186.0 M.G.L.
RIVERSIDE PARK
MEMPHIS
TENNESSEE
MISSISSIPPI
RIVER
PROTECTIVE
DIKE NO. 2
BATTURE
RIPRAP
ASPHALT CONCRETE
DREDGE CUT
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
MEMPHIS GAGE (U.S.W.B.)
S.M.L.W. 186.5 M.G.L.
U.S. ENGINEER DEPOT
S.M.L.W. 185.5 M.G.L.
1947 TOP BANK
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ASPHALT PAVING
ERODIBLE BANK
GRAVEL REVETMENT ON MODEL
INDUSTRIAL FILL
REVETTED BANK
EXISTING DIKES
PROPOSED DIKES
DIKES PROPOSED FOR REMOVAL
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.)
M.R.C. HORIZONTAL DATUM.
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN 6 - TEST 9
1937 FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 20

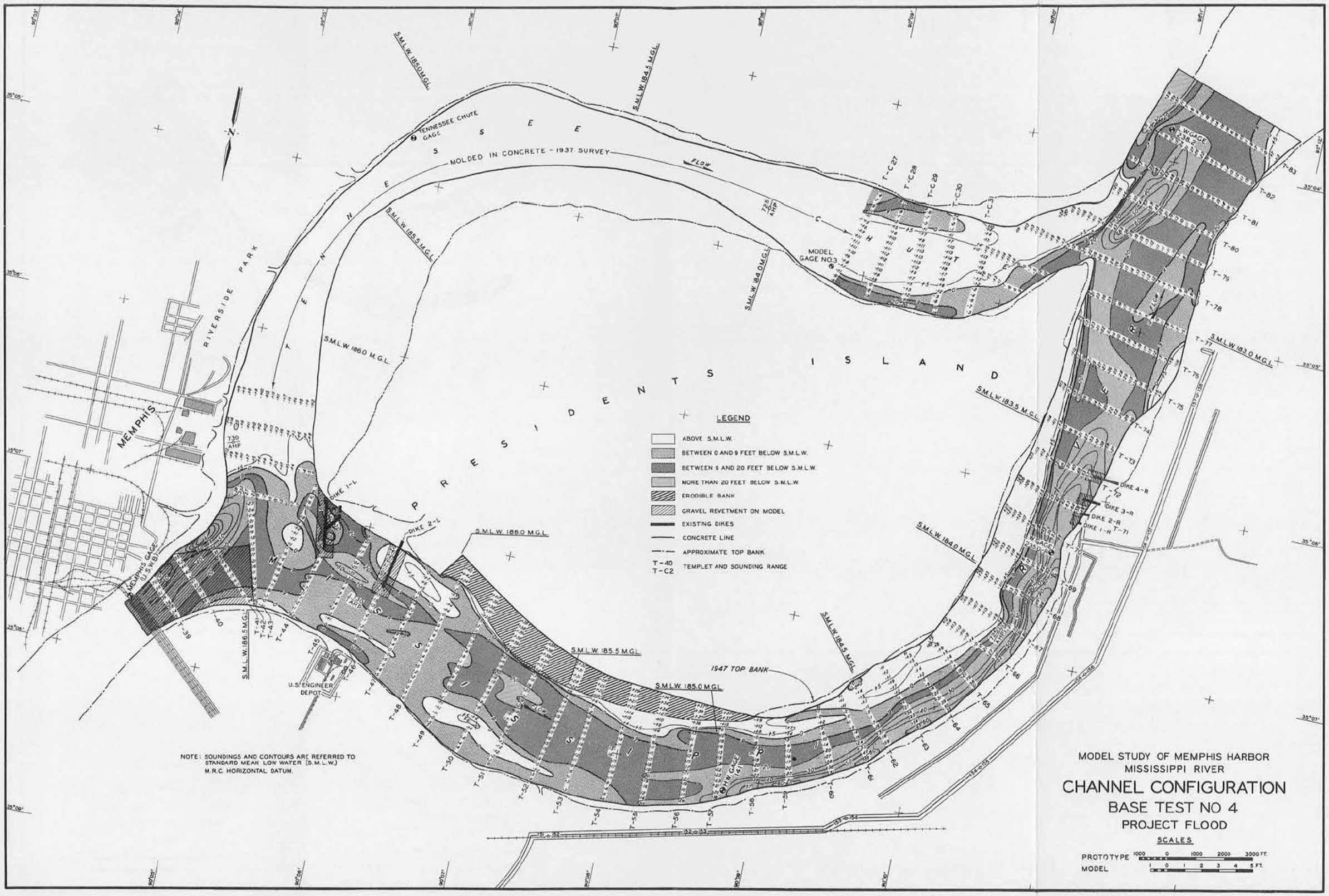

TENNESSEE CHUTE
GAGE
MOLDED IN CONCRETE - 1937 SURVEY
FLOW
MODEL GAGE NO 3
W GAGE 28.2
RIVERSIDE PARK
MEMPHIS
MEMPHIS GAGE (U.S.W.B.)
U.S. ENGINEER DEPOT
1947 TOP BANK
H.W. GAGE 141
DIKE 1-L
DIKE 2-L
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 184.5 M.G.L.
730 AHP
725 AHP
740 AHP
T-C27
T-C28
T-C29
T-C30
T-C31
T-39
T-40
T-41
T-42
T-43
T-44
T-45
T-46
T-47
T-48
T-49
T-50
T-51
T-52
T-53
T-54
T-55
T-56
T-57
T-58
T-59
T-60
T-61
T-62
T-63
T-64
T-65
T-66
T-67
T-68
T-69
T-70
T-71
T-72
T-73
T-74
T-75
T-76
T-77
T-78
T-79
T-80
T-81
T-82
T-83
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ERODIBLE BANK
GRAVEL REVETMENT ON MODEL
EXISTING DIKES
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 T-C2 TEMPLET AND SOUNDING RANGE
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM.
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
BASE TEST NO 4
PROJECT FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 21

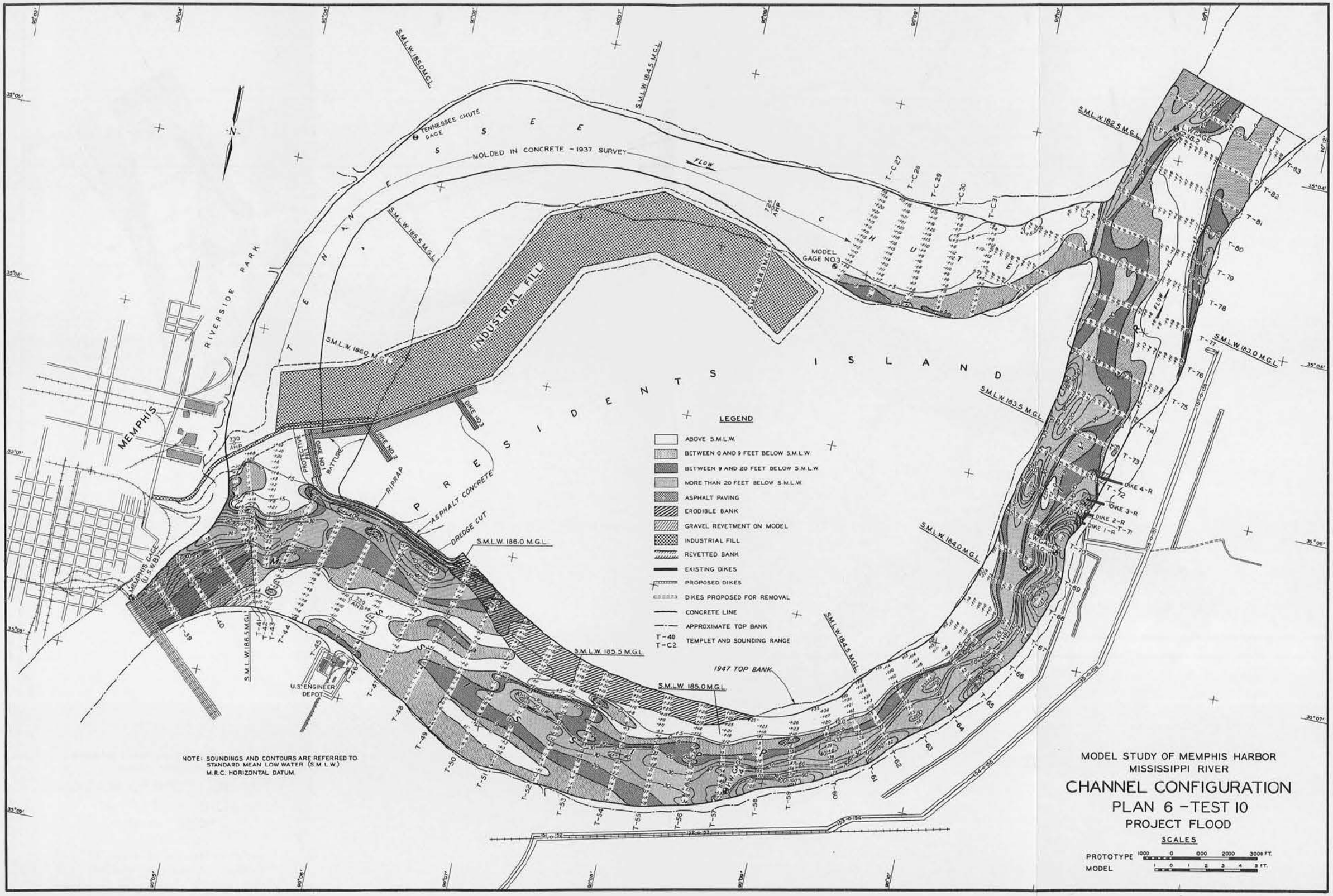

TENNESSEE CHUTE GAGE
MOLDED IN CONCRETE - 1937 SURVEY
FLOW
725 AHP
MODEL GAGE NO.3
INDUSTRIAL FILL
RIVERSIDE PARK
MEMPHIS
MEMPHIS GAGE (U.S.W.B.)
730 AHP
239 AHP
PROTECTIVE DIKE NO.1
BATTURE
DIKE NO.2
DIKE NO.3
RIPRAP
ASPHALT CONCRETE
DREDGE CUT
U.S. ENGINEER DEPOT
1947 TOP BANK
TENNESSEE
RESIDENTS
ISLAND
S.M.L.W. 185.0 M.G.L.
S.M.L.W. 184.5 M.G.L.
S.M.L.W. 185.5 M.G.L.
S.M.L.W. 184.0 M.G.L.
S.M.L.W. 186.0 M.G.L.
S.M.L.W. 186.5 M.G.L.
S.M.L.W. 182.5 M.G.L.
S.M.L.W. 183.0 M.G.L.
S.M.L.W. 183.5 M.G.L.
DIKE 4-R
DIKE 3-R
DIKE 2-R
DIKE 1-R
LEGEND
ABOVE S.M.L.W.
BETWEEN 0 AND 9 FEET BELOW S.M.L.W.
BETWEEN 9 AND 20 FEET BELOW S.M.L.W.
MORE THAN 20 FEET BELOW S.M.L.W.
ASPHALT PAVING
ERODIBLE BANK
GRAVEL REVETMENT ON MODEL
INDUSTRIAL FILL
REVETTED BANK
EXISTING DIKES
PROPOSED DIKES
DIKES PROPOSED FOR REMOVAL
CONCRETE LINE
APPROXIMATE TOP BANK
T-40 TEMPLET AND SOUNDING RANGE
T-C2
NOTE: SOUNDINGS AND CONTOURS ARE REFERRED TO STANDARD MEAN LOW WATER (S.M.L.W.) M.R.C. HORIZONTAL DATUM.
MODEL STUDY OF MEMPHIS HARBOR
MISSISSIPPI RIVER
CHANNEL CONFIGURATION
PLAN 6 - TEST 10
PROJECT FLOOD
SCALES
PROTOTYPE 1000 0 1000 2000 3000 FT.
MODEL 1 0 1 2 3 4 5 FT.

PLATE 22